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Bulk power facilities SW Ontario

Submission to the
Royal Commission on
Electric Power Planning
December 1978

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Requirement for Additional Bulk Power Facilities in Southwestern Ontario

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Submission of

ONTARIO HYDRO

to the

Royal Commission

on Electric Power Planning

December 1978

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Synopsis

The existing and approved transmission facilities from the Bruce Nuclear Power Development are not adequate for the incorporation of Bruce Generating Station (GS) B in addition to Bruce GS A and Douglas Point GS.

The critical area load in southwestern Ontario is forecast to grow at an annual rate of 5.5% from 1978 to 1987 and 5.2% from 1987 to 2001. A number of stop-gap measures are being implemented which will increase the capability of the existing transmission facilities. By the winter of 1987/88 major new bulk power facilities will be required for the supply to customers in southwestern Ontario.

The earliest possible time by which major new facilities can be installed is late 1986. The planning process for the provision of additional facilities must be continued in an orderly way if the required in-service dates are to be met. Confirmation of the need for such facilities is therefore requested from the Royal Commission on Electric Power Planning.

1.0 Introduction:

On July 11, 1974, the Ontario Government announced that it would hold public hearings into the long range planning of Ontario's electric power system. On March 13, 1975, the Honourable Allan Grossman, Provincial Secretary for Resources Development, announced in the Legislature the Government's decision to establish an independent commission of enquiry to hold these hearings. He stated, "The Commission will focus on the broad conceptual consequences of alternative ways of supplying power during the period 1983 to 1993". The March 13, 1975, statement also noted that there are certain electric power generating and transmission projects that Ontario Hydro considers must be initiated during the tenure of the Commission. The original terms of reference with respect to these projects were amended by Order-in-Council 2065/78 dated July 12, 1978, a copy of which is attached to this submission as Appendix A. Rather than concentrate on the need for certain specific transmission connections, the amended terms of reference call for an examination of the need for, and timing of, additional bulk power facilities within broad geographic areas.

This submission deals with the requirement for additional bulk power facilities in southwestern Ontario which, for the purposes of the Royal Commission's examination of need, is considered to be that area south of Bruce Nuclear Power Development and west of a line through Essa Transformer Station (TS) and Nanticoke Generation Station (GS). This is shown in Figure 1.

There are four main requirements for major new supply facilities in southwestern Ontario:

(a) Incorporation of Bruce GS B

Studies have shown that the existing and approved transmission facilities from the Bruce Nuclear Power Development are inadequate to incorporate Bruce GS B in addition to Bruce GS A and Douglas Point GS. Major new transmission facilities are needed to meet this requirement.

(b) Load Supply

There is an urgent requirement for major new transmission lines and transformer stations in southwestern Ontario to supply the growing load in that part of the province, in particular the load in the Kitchener, London, Sarnia and Windsor areas.

(c) Interconnections

Another requirement is to reinforce the interconnections with the Michigan Electric Power Pool in the vicinity of Sarnia and Windsor. An interconnection is a transmission line which directly connects adjacent electric utilities. Interconnections are mutually advantageous to the interconnected electric utilities, providing advantages of improved system reliability and reduced costs. The advantages are discussed in the Ontario Hydro Information Memorandum to the Royal Commission on Electric Power Planning, entitled "System Interconnections", dated June 1976 (Exhibit 23-0). Interconnections also have their disadvantages but these are outweighed by their advantages.

If the advantages of interconnections are to be realized, the internal transmission of each of the interconnected power systems must be adequate to support interchanges of power in both directions over the interconnections. A utility has a responsibility to design its own system so that it can provide assistance to the other systems if it expects to obtain assistance from them.

The Ontario Hydro system has for many years been interconnected with the Detroit Edison Company in the State of Michigan by transmission interconnections across the St. Clair and the Detroit rivers. There are four interconnections with Detroit Edison which, along with other interconnections with utilities in New York State, permit the Ontario Hydro system to operate in synchronism with the large power grid covering much of eastern North America.

If the advantages of interconnections are to remain commensurate in the future with those of the past, the capability of the bulk power system to support transfers of power over the interconnections must keep pace with the growth of the Ontario Hydro system.

The requirement to reinforce the interconnections does not determine the required in-service date for new facilities but it is one of the factors which must be considered in the development of a system plan.

(d) Incorporation of Future Generating Stations

It is expected that before the year 2000 at least one additional thermal generating station located in the Niagara Peninsula or southwestern Ontario will be required. The incorporation of this station into the bulk power system will require new transmission. Since any such station could not be in service before the 1990's, this transmission requirement does not occur as soon as the first

two requirements but along with interconnections it must be considered when developing an overall plan.

2.0 Requirement for New Bulk Power Transmission from Bruce

2.1 Approval of Bruce GS B

On November 4, 1975 the Honourable Dennis R. Timbrell, then Minister of Energy advised that final Cabinet approval had been given "to construct and operate a 4x800 megawatt nuclear fuelled generating station at the Bruce Nuclear Power Development, with a first unit in-service date of 1982, to be followed by two units in 1983 and one in 1984..."

The current first synchronizing and commercial in-service dates for these units are:

	1st Synch.	Commercial In-Service
First Unit	November 82	October 83
Second Unit	November 83	July 84
Third Unit	November 84	April 85
Fourth Unit	August 85	January 86

2.2 Description of Existing and Approved Transmission Facilities from Bruce Nuclear Power Development

At the present time the Bruce Nuclear Power Development is connected to the bulk power grid by two 2-circuit 230 kV transmission lines. A third 2-circuit 230 kV line with one circuit strung connects the Bruce Complex with the 115 kV transmission system in the Owen Sound area via a 250 MVA 230-115 kV autotransformer. Construction of a 500 kV 2-circuit transmission line between the Bruce Complex and the 500 kV bulk power grid at Milton TS has been approved and is scheduled for service in 1979. The geographic locations of the present and approved transmission facilities are shown on Figure 2. Technical details are shown on Figure 3.

2.3 Capability of Existing and Approved Facilities

Ontario Hydro Information Memorandum to the Royal Commission on Electric Power Planning entitled "The Transmission Planning Process" (Exhibit 22-0) describes in some detail the methods and criteria used in planning the bulk power system. Ontario Hydro, as a member of the Northeast Power Co-ordinating Council (NPCC), has agreed to design its bulk power system in accordance with the

NPCC document "Basic Criteria for Design and Operation of Interconnected Power Systems". A copy of this document is contained in the Ontario Hydro Information Memorandum entitled "Reliability" (Exhibit 20-0).

To assist in maintaining the stability of the Bruce generating stations for the above criteria, Ontario Hydro uses a number of control techniques. The principal methods employed are the use of high speed excitation systems with power system stabilizers on its large generators and the use of generation rejection. It is desirable to limit the use of generation rejection and the amount of generation rejected for the following reasons:

(a) It imposes severe stress on the turbine-generator unit which could lead to serious damage.

(b) With nuclear units, reactors may experience a temporary decrease in reactivity causing them to lose their ability to sustain a chain reaction and making them unavailable for re-start for up to two days. This would mean additional replacement energy costs of about $500,000 per unit (1978 dollars) for each occurrence and could lead to a generation shortage if several units were involved.

(c) If the amount of generation rejected is too large it can cause cascading outages on the interconnected systems.

In view of these considerations it is Ontario Hydro's design practice to limit the use of generation rejection on thermal generation units to conditions which occur very infrequently. Therefore, generation would not be rejected for a single contingency event such as loss of a 2 circuit transmission line with all other facilities in service. Generation rejection would, however, be used in the case of loss of a 1 or 2 circuit line with one circuit already out of service.

A further consideration in determining the amount of generation which can be rejected is the effect of the rejection on the integrity of the interconnected systems. In order to avoid jeopardizing the integrity of these systems, it will be necessary to limit the rejection of Bruce generation to two units, or, if more than two units must be rejected it will also be necessary to provide for the rejection (disconnection) of an equivalent amount of customer loads.

Transient stability studies of the system, with the existing and approved transmission facilities in place and full output from Bruce GS A and B and Douglas Point GS, show that to avoid transient instability for a double circuit outage of the Bruce GS x Milton TS 500 kV line, the rejection of 6 Bruce GS generators

will be required. In order to avoid jeopardizing the integrity of the interconnected system for this large generation loss, it will be necessary to reject about 3000 MW of load. Alternatively, generation rejection could be limited to two Bruce units and the output of the Bruce complex limited to about 3000 MW which would result in about 3000 MW of nuclear generation being locked-in with extremely large economic penalties. It is desirable to have a second line from Bruce GS in service by November 1982, the synchronizing date of the first unit at Bruce GS B. However the earliest possible in-service date is now late 1986. Therefore it is essential that new transmission facilities be provided as soon as possible.

3.0 Supply to Southwestern Ontario:

3.1 Planning to Meet Future Loads:

Prudent planning of an electric power system requires continual attention to the relationship between the capability of the system facilities and the demands which are placed on these facilities by the electric load. This implies the anticipation of future load growth in each area and the appropriate additions to the system facilities in time to supply these future loads.

3.2 Load Growth in Southwestern Ontario

3.2.1 General

Southwestern Ontario occupies a pivotal position in the Canadian economy with effects that spread far beyond its own confines. The demand for electricity in the area has tended to reflect its importance and is forecast to grow at rates only slightly lower than those which have prevailed in the past.

Southwestern Ontario contains some of Canada's richest farm land and is an important source of food for the whole nation. Modern high productivity farming techniques have made the agricultural sector an important and rapidly growing user of electric power. Heating and climate control in poultry farming, grain drying and bulk milk refrigeration in the dairy industry are just a few examples of the extensive use of electric energy by the farming community.

Southwestern Ontario has to a great extent been a point of entry for new industries coming into Canada from the United States which have often tended to establish initially at points close to the United States border and to move at a later date to other parts of Ontario. The automobile and petrochemical industries, together with their ancillary industries such as rubber, glass, plastics and electronics, have all had a pervasive influence on

Line Number

the economy of southwestern Ontario leading to concentrations of population in urban areas of significant size.

The fortunes of the automobile industry in particular have had a dramatic impact upon the demand for electricity, as indicated by the growth rate before and after 1965 when the Canada-US Auto Pact came into being.

3.2.2 The Load Forecast

For purposes of administration, the Ontario Hydro system is divided into Operating Areas. The operating areas contained in the area south of Bruce and west of a line through Essa TS and Nanticoke GS are shown on Figure 1. The actual and forecast load for December for each of these areas except Barrie, Brampton, Dundas and Cayuga are tabulated in Figures 4A to 4P inclusive. These Operating Area loads are not tabulated as they are not supplied from the transmission facilities under study. December values are used to indicate growth trends because the historical records are more readily available although as stated below, January loads are used to assess requirements. A graphical representation of the forecasts is shown in Figure 5.

The load in each operating area is segregated by user class into three components:

a) Municipal - the power supplied to the municipal electric utilities for resale.

b) Retail - the power supplied at retail rates to customers outside the municipalities by Ontario Hydro facilities.

c) Direct Industrial - the power supplied directly by Ontario Hydro at wholesale rates to industrial customers.

The load in the study area varies throughout the day, from day to day during the week, and from season to season throughout the year. The peak loads over the winter period impose the most severe duty on the existing facilities and determine the timing of the requirement for new facilities, and for the area under study this is forecast to occur in January. Therefore, this study of system adequacy is based on load forecast for January.

The supply of loads in the Kitchener, London, Sarnia and Windsor areas shown enclosed in the shaded area in Figure 1 is particularly important in determining the capability of the existing bulk power transmission system. It is these loads which determine the power flowing on the most critically loaded facilities which supply southwestern Ontario. The forecast coincident January peak load by station in this area is tabulated

for selected years in Figure 6 and shown graphically in Figure 7. The average forecast growth rate of this load is 5.5% from 1978 to 1987 and 5.2% from 1987 to 2001.

This forecast is based on interviews with municipal utilities, direct customers and Operating Area managers and also upon information supplied by builders and developers. The projection of the forecast beyond 1987 is based upon the assessment of past response to economic and social factors and the expected course of these factors in the future.

3.2.3 The SRI-CEA Econometric Model

3.2.3.1 General

The model was developed by the consulting firm SRI International at the request of the Canadian Electrical Association (CEA)*. The purpose of this mathematical model is to project the long term demand for electric energy by end use.

In order to obtain a forecast from the model, it is necessary to make separate forecasts of a number of variables such as population, industrial production and gross domestic provincial product (GDPP) and to estimate the parameters required to provide the dynamic relationship between the variables and the demand for electricity. Therefore a reasonable forecast is obtained only if reasonable and consistent estimates of the variables are combined with reasonable and consistent estimates of the parameters. Further, the model is structured in such a way that it cannot forecast new relationships between energy use and the variables considered or other variables that may be important in the future.

The model was developed quite recently and Ontario Hydro has had limited experience with its use. A great deal of experience will be required to determine the model's capabilities and limitations. While the economic data required by the model is available on a provincial base, not all of it is available for Regions of the Province as required by the study. Other models are also being developed which will provide information for comparison with the SRI-CEA model.

The SRI-CEA model is useful in understanding questions such as the following:

(1) For a set of economic assumptions, what are likely ranges in growth rates for electricity use?

(*) "Long Range Electricity Forecast for Canada - A Methodology," November 1978, by SRI International, for the Canadian Electrical Association.

(2) If another Arab oil embargo is initiated (bringing higher oil prices), how will that influence the demand for electricity?

(3) What will be the impact on energy demand of increasing electric rates in the residential, industrial, and commercial sectors?

(4) If gas prices rise rapidly, what impact will that have on the consumption of electricity for residential space and water heating?

(5) How will changes in the expansion rate of the provincial economy affect the use of electricity in residences, in commerce, and in industry?

(6) If a certain industry expands production, what effect will that have on the use of electricity?

(7) Where can development effort be best employed to improve the quality of load forecasts?

3.2.3.2 Model Structure

The conceptual framework used in the SRI-CEA model to forecast energy use is shown in Figure 8. On the right side of the figure are shown the economic variables that influence the demand for energy in each end use application. The end use markets themselves appear in the centre and the left side shows the energy sources that supply the market. The end uses were selected on the basis of their relative size and importance in the marketplace for electricity in Canada. Broadly speaking, the markets are the residential, agricultural, commercial and industrial (manufacturing and mining) sectors.

For each end use, the quantity of electricity demanded is analytically related to appropriate economic and industrial indicators. The structural form of these relationships was developed based on a consideration of market behaviour, availability of data, simplicity of equation form, and reasonableness of computed results.

The industrial demand for electricity is dependent on the patterns of electricity use and levels of production in specific industries. In industry, pulp and paper, chemical, steel, and aluminum and the mining of iron, copper, and coal each require large quantities of electricity, predominantly for motor drive and electrolytic processing. Thus, future consumption of electricity is directly correlated with industrial production. Electricity use by all other industries, referred to in the SRI

report as "light manufacturing", is correlated with general levels of manufacturing activity--that is, value added in manufacturing.

In the residential sector, three separate markets were analyzed. Total energy requirements for (1) space heating, (2) water heating and (3) electric appliances. The energy requirements for each of the first two were correlated on the basis of per-capita use with GDPP per capita, energy prices, and a lag parameter. The form of the estimating equation has terms for income and price elasticity coupled with a lag parameter. The share that electricity will capture in these competitive heating markets was related to housing trends and the price of electricity relative to gas and/or oil. Electricity use for appliances was also correlated on a per capita basis with GDPP per capita, electricity prices, and a lag term.

A similar approach was employed in the commercial sector, where energy use per service employee was correlated with GDPP and price.

Thus, the principal economic variables used in the model to forecast the demand for energy are:

- Gross Domestic Provincial Product (GDPP)
- Population
- Total Employment
- Service employment
- GDPP/Manufacturing
- GDPP/Agriculture
- Production of the pulp and paper, chemical, steel, aluminum and mining industries.

The parameters used in the model are estimated on the basis of historical relationships. These parameters include income and price elasticities and lag parameters, market share parameters and gross economic parameters. These are listed and their use described in Appendix B. SRI have indicated that these parameters should be viewed as their best initial estimates for Ontario as a whole and that they should be revised when increased understanding and knowledge of particular markets is obtained.

3.2.3.3 Scenarios Considered

The SRI-CEA model was used to project future growth in electric energy consumption for three scenarios in which the growth rate of the Ontario Gross Domestic Provincial Product was varied. The GDPP growth rates used and the resultant growth rates in electric energy consumption are shown in Figure 9 together with Ontario Hydro's 1978 forecast of peak growth rates. The SRI-CEA forecast

of electric energy consumption is also shown graphically in Figure 10 for each scenario. The detailed output of the model for several years for each scenario is provided in Appendix C.

Scenario #1 is the reference forecast using the parameters suggested by SRI when they developed the model. The SRI reference forecast used rates of growth in GDPP of 3.8% to 1990 and 3.2% thereafter. These result in an average annual growth rate in electric energy consumption of 4.0% in the period to 2000.

Scenario #2 illustrates the effect of using GDPP growth rates approximately the same as those published in December 1977 by the Ontario Economic Council (OEC)*. These rates are 5.3% per year to 1981, then 4.4% per year to 1985 and 4.1% per year thereafter. These result in a forecast average annual growth rate in electric energy consumption of 5.1% in the period to 2000.

Scenario 3 illustrates the effects of high growth in which GDPP is assumed to grow at a rate of 5.5% until 1985 and at 4.5% thereafter. These result in a forecast average annual growth rate in electric energy consumption of 5.8% in the period to 2000.

The SRI model shows how the growth in electric energy consumption is dependent on the forecast of total economic activity in the province. It is also capable of examining the effects of changes in the other major variables on consumption of electrical energy.

3.3 Existing Supply Facilities

The existing bulk power supply facilities in southwestern Ontario are most easily described in two parts, namely those facilities which supply the Kitchener area, and those which supply the London - Sarnia - Windsor area.

3.3.1 Kitchener Area Bulk Power Supply Facilities:

At the present time, bulk power to the Kitchener area can be supplied over four 230 kV 2 circuit steel tower transmission lines which terminate at Detweiler TS located southwest of the city of Kitchener. In addition to supplying power to this part of the province, these lines are also an integral part of the provincial grid. The geographic locations of these lines are shown in Figure 2 and technical details such as lengths, conductor sizes and present ampacities are shown on the schematic diagram, Figure 11.

(*) "The Ontario Economy 1978-1987", December, 1977; by J.A. Sawyer, D.P. Dungan, and J.W.L. Winder for the Ontario Economic Council.

Line
Number

3.3.2 London - Sarnia - Windsor Area Bulk Power Supply Facilities

Bulk power is normally supplied to the London - Sarnia - Windsor area over 230 kV lines from Detweiler TS, from Middleport TS near Hamilton, and from thermal generating stations located within the area. In addition, the four interconnections with Detroit Edison Co. permit interchange of energy and power between Ontario Hydro and US utilities. Details of these facilities are given below.

3.3.2.1 Transmission Facilities

The geographic locations of the transmission lines are shown in Figure 2 and technical details such as length, conductor sizes and ampacities prior to uprating are shown on the schematic diagram, Figure 11.

3.3.2.2 Thermal Generating Stations:

- At Lambton GS near Sarnia, four 500 MW coal-fired generators are installed. Each of these units have a maximum December peak output of 525 MW and a maximum continuous rating (MCR) of 495 MW.

- At J. Clark Keith GS in Windsor, four 64 MW coal-fired units are installed. Each of these generating units has a maximum December peak output of 64 MW and a MCR of 63.5 MW. At present this station has been de-commissioned as an economy measure. It is planned to re-commission it in 1980 with modifications which will enable it to meet air quality requirements.

3.3.2.3 Combustion Turbine Generating Sets:

- At Sarnia-Scott TS, four light oil fuelled, combustion turbine driven generating sets (CTU'S) of 17.75 MW capacity each are installed.

- At Lambton GS, four CTU's of 7.5 MW capacity each are also installed.

- At J. Clark Keith GS in Windsor, a single 7.0 MW CTU is installed.

3.3.2.4 Interconnections with U.S. Utilities:

Interconnections with the Detroit Edison Co. in Michigan consist of four tie lines all under 4 miles in length. Tie lines B3N, L4D and L51D cross the St. Clair River into Michigan near Sarnia

while the remaining tie line, J5D, crosses the Detroit River into Michigan in the vicinity of Windsor.

3.3.3 Stop-gap Measures

3.3.3.1 General

In order to meet the forecast loads up to about January 1987, it is planned to implement a number of stop-gap measures which include increases in circuit ampacities and the installation of large amounts of static capacitors. While there is no alternative to the stop-gap measures, they could result in a significant reduction in system reliability. They involve the extensive use of engineering solutions which are a major extrapolation of existing practices and which could introduce unforeseen problems. The proposed stop-gap measures are discussed in more detail in the following sections.

3.3.3.2 Transmission

The critical circuits of the existing bulk power transmission system in southwestern Ontario are shown in Figure 11. Some of the circuits will soon be overloaded and it is planned to increase their capacities in one or more of the ways discussed below:

(a) High Temperature Operation

Aluminum Cable Steel Reinforced (acsr) transmission line conductors have usually been operated at temperatures of up to 90°C or lower in normal conditions and up to 125°C in emergency conditions. Ontario Hydro has carried out extensive field and laboratory tests to determine the practicality of operating the existing acsr conductors at higher temperatures or replacing them with conductors which can be operated at higher temperatures.

These tests have indicated that operating temperatures of up to 150°C are permissible. This is a considerable increase over past practice and significantly higher than used by other utilities.

For example a 1977 report* by a CIGRE study committee of utilities in Germany, England, Ireland, France, Belgium and Hungary indicates that maximum conductor temperatures for emergency operation range from 50°C to 110°C with most of the values being either 75°C or 80°C.

(*) CIGRE Committee 31, Working Group 31-02 Reference Number 3177 (GT02) 01.

In order to allow for the increased conductor sag at the higher temperatures planned by Ontario Hydro, it is required in most cases that the tension of the conductors be increased or that the conductors be raised by adding extensions to the existing towers.

(b) <u>Replacement of Conductors</u>

In some cases additional capacity can be obtained by replacing the existing conductor by a conductor with a larger aluminum cross-section where the structural design of the existing towers will permit.

(c) <u>Summary of Planned Capacity Increases on Existing 230 kV Transmission Lines in Southwestern Ontario</u>

The work which it is practicable to do on each of the existing circuits has been determined by a study of the individual circuits. The following table shows for each of the most critical circuits in southwestern Ontario, the ratings prior to and after uprating. Except for circuits D6/7V where a lesser rating is adequate, the planned ratings are based on a conductor temperature of $150^{\circ}C$. Although it is considered acceptable to operate acsr conductors at temperatures of $150^{\circ}C$., there has been very little experience in the industry with such temperatures. Therefore, unexpected troubles could occur in service, and it must be accepted that the circuits will likely be less reliable than when operated more conservatively. A similar observation can be made about the structural security of the transmission line towers. When they have been restrung with conductors having a higher capacity, they will be adequate in so far as their structural capability will exceed the minimum loading standards of the Canadian Standards Association. However, there will be less reserve capability than now exists to withstand the severe storm conditions which may occur, although infrequently.

Summary of Capacity Increases Planned
on Existing 230 kV Transmission Lines
In Southwestern Ontario

		Winter Ampacity	
		Prior To Uprating (Amperes)	Uprated (Note 1) (Amperes)
230 kV 1 cct Line Middleport TS x Buchanan TS	M31W	1220	2040
230 kV 2 cct Line Middleport TS x Buchanan TS	M32/33W	1790	2600
230 kV 2 cct Line Detweiler TS x Buchanan TS	D4/5W	1310	2040
230 kV 2 cct Line Detweiler TS x Orangeville TS	D6/7V	1390	1650
230 kV 2 cct Line Middleport TS x Detweiler TS	M20/21D	1710	2600

Note 1 Uprated by reconductoring and/or raising towers.

3.4 Capability of Existing System (Including Stop-Gap Measures)

The capability of the existing bulk power transmission system to meet the following normal criteria was determined assuming that the stop-gap measures described above are implemented and that static capacitors are provided to maintain adequate voltage levels.

A) loss of a 2 circuit line with all other circuits in service; one unit in service at Lambton GS; and zero net interchange with Michigan.

B) Loss of a 2 circuit line with one circuit already out of service; three units in service at Lambton GS; and zero net interchange with Michigan.

C) Loss of a single circuit with all other circuits in service; three units in service at Lambton GS; and a 2000 MW sale to Michigan.

These conditions reflect the intent of the NPCC "Basic Criteria" referred to in Section 2.3 above.

In addition to the power flows required to supply the load and to support any sales to US utilities, there is a circulating power flow around Lake Erie as explained in the Information Memorandum entitled "System Interconnections" (Exhibit 23-0). Even with no net import or export of power with US utilities, there is usually a flow of power over the interconnections with power leaving Ontario to Michigan and simultaneously returning to Ontario from New York (or vice versa). This is known as circulating power. While studies are continually being carried out to determine the likely magnitude of this circulating power, it is impractical to predict its magnitude with any degree of exactness more than a few years in advance. For this study, it has been assumed that prefault circulating power will be approximately 300 MW with condition A, and approximately 500 MW coincident with conditions B & C, counterclockwise around Lake Erie.

It should be noted that the above system conditions were evaluated only on the basis of the ampacities of the critical circuits and the maintenance of acceptable voltage levels at bulk power system delivery points. Consideration of another critical power system parameter, transient stability, could well result in some reduction in these capability limits.

Computer studies show that the amounts of southwestern Ontario load which can be supplied under conditions A, B and C are 4,100 MW, 4,500 MW and 4,300 MW respectively. Condition A, loss of a 2 circuit line with all other lines in service, one unit at Lambton GS in service and zero net interchange with Michigan, is the most limiting condition and requires that additional transmission facilities be provided in 1987. Figure 12 shows this capability plotted on the load growth curve. Figures 13, 14 and 15 show results of computer simulation of the system conditions A, B and C. The power flows for each circuit and the voltages at each station are indicated. Circuits out of service are indicated with the symbol O/S.

The conditions discussed above are for the forecast load, which is the most likely value of load. If the load growth rate were to be higher than this forecast amount, the existing facilities would be inadequate sooner, and if the rate were to be lower, the reverse would be true. This is illustrated in Figure 16 in which a high and a low forecast (average annual growth rates of about 6% and 4% respectivly) have been superimposed on Figure 12. This shows that the need for new facilities would be advanced 2 years with the high forecast and deferred 4 years with the low forecast.

3.5 Effect of System Power and Energy Losses

There are two undesirable effects of resistive transmission line losses on the operation of the bulk power system. The first is increased fuel consumption and the second is a requirement for additional generating capacity. It should be noted that the line losses generally reach a peak at the same time as the load.

Excessive losses thus impose a two-fold cost penalty on the power system, and there is every incentive, therefore, for the electric utility to keep transmission losses low. Not only does it help to reduce costs to its customers, but it also helps to achieve the goals of energy conservation and the conservation of scarce capital resources.

Losses in an electrical transmission line are proportional to the square of the current that it is required to carry. For example, if the current on a line is increased to 10% above normal, the losses will increase to 21% above normal. There is thus a practical limit to the amount of power which can be carried economically on any particular line at a given voltage level. The stop-gap measures which have been described above in section 3.3.3 for uprating the existing facilities all tend to push the operation of these 230 kV lines in an uneconomic direction.

A graph of system power losses in southwestern Ontario at time of January peak loads is shown in Figure 17. As can be observed in this graph, system losses are approximately 260 MW in January, 1987. It is estimated that these losses are about 85 MW more than they would be if 500 kV transmission had been provided. Based on the value of replacement energy and excluding any capacity charges, the annual cost in 1987 of the additional losses is over 11 million dollars, or in terms of fuel, about 160,000 tons of US coal.

3.6 Static Capacitor Requirements

In addition to increasing resistive power losses, increased transmission line loadings also result in increased reactive power losses. Unlike resistive power losses, which can be mitigated to a certain extent by re-conductoring with larger conductor, reactive power losses are largely determined by the geometry of transmission line construction. This type of loss is also proportional to the square of the current flowing in the line, and has a large effect on the regulation of voltage at the terminals of lines which are carrying high currents. Maintaining adequate voltage levels at bulk power delivery points is important both for system stability considerations and to provide satisfactory voltage for customers' equipment. Banks of static capacitors are required to compensate for the reactive power

losses in the transmission system, not only under normal conditions with all lines in service but also at times when transmission circuits are out of service. Expensive switching equipment must also be provided to switch the capacitor banks on and off the system in response to changing system conditions.

A graph of system static capacitor requirements is shown in Figure 18. The graph shows a requirement of 1700 MVAR in January 1986 and 2000 MVAR in January 1987, an increase in capacitor requirements of approximately 300 MVAR. In 1979 dollars, capacitor banks cost $8,200 per MVAR.

4.0 Conclusions

With respect to the first requirement, the incorporation of Bruce GS B, it would have been desirable to have a transmission line in service by November 1982, the synchronizing date for the first unit at Bruce GS B, because the existing and approved transmission lines are not adequate to incorporate this plant. However, the earliest possible in-service date for a new transmission line is late 1986. Planning should proceed now to provide new transmission as soon as possible for the incorporation of Bruce GS B.

With respect to the second requirement, the supply of power to southwestern Ontario, the earliest possible year by which major new facilities could be provided is also late 1986. For the following reasons, planning should proceed now to provide for the necessary facilities.

A If the load grows at the forecast rate, the capability of the existing facilities (including stop-gap measures) to supply it with adequate reliability will be exceeded in the winter of 1987/88.

B New transmission facilities installed by the winter of 1987/88 could reduce the power losses in supplying the southwestern Ontario load by about 85 MW. The decreased losses would be equivalent to a reduction in system load and, therefore, would effectively increase the capability of the Ontario Hydro system to meet the load, or alternatively to make profitable sales of unused surplus generating capacity to other utilities.

C The annual cost of the bulk power transmission losses will increase rapidly. It is estimated that the savings in losses in 1987 by the addition of new transmission facilities would be over 11 million (in 1987 dollars)

considering energy cost only and including no capacity charges.

D If the load growth proves to be greater than forecast, the need for new facilities will be even more pressing. However, it is impractical to speed up the process of obtaining approvals, acquiring property rights and constructing the new facilities. On the other hand, if the load growth proves to be less than forecast it would be possible to delay construction.

The bulk of the expenditures for major new facilities scheduled for service in 1986 do not have to be committed until about 1982. It is at that time that the factors outlined above will be reviewed finally and a decision made whether or not to proceed with design and construction. However, if the option of having the facilities in service by 1986 is to be retained, the process now under way of studying alternatives, selecting a plan and specific locations for facilities must continue. In other words, for several years ahead, the project can be cancelled or deferred without incurring any loss except for the cost of the on-going studies.

APPENDIX A

Copy of Order in Council Document

OC-2065/78, dated July 12, 1978

Ontario

Executive Council

O.C. 2065/78

Copy of an Order-in-Council approved by Her Honour the Lieutenant Governor, dated the 12th day of July, A.D. 1978.

The Committee of Council have had under consideration the report of the Honourable the Provincial Secretary for Resources Development, wherein he states that,

WHEREAS the Royal Commission on Electric Power Planning was appointed pursuant to The Public Inquiries Act, 1971, and its terms of reference were established by Order-in-Council numbered OC-2005B/75 dated 17th July, 1975;

AND WHEREAS paragraph 4 of Order-in-Council numbered OC-2005B/75 called for the Commission to consider and report on certain projects on a priority basis;

AND WHEREAS by Order-in-Council numbered OC-3489/77 the Royal Commission on Electric Power Planning was requested to provide its interim report on issues relating to nuclear power in Ontario by June 30, 1978;

AND WHEREAS since July, 1975, revisions have been made in the projections of electric load growth expected to occur in Ontario Hydro's East System before 1988, and beyond that date to the year 2000;

AND WHEREAS, in part as the result of such load growth revisions for the period beyond 1987, it is no longer necessary for the Royal Commission to

consider and report on a priority basis on the North Channel generating station;

AND WHEREAS in light of the passage of The Environmental Assessment Act, 1975, which followed the approval of the Royal Commission's terms of reference, the description of specific transmission connections set out in paragraph 4 of the terms of reference is no longer appropriate and should be replaced by an examination of the need for, and the timing of, additional bulk power facilities within broad geographic areas;

AND WHEREAS it is desirable to have the Royal Commission on Electric Power Planning review the need for, and the timing of, additional bulk power facilities and to report thereon to the Ministry of Energy, and for the specific nature of additional bulk power facilities which might then be proposed, including their locational and environmental aspects, to be reviewed by the Environmental Assessment Board;

AND WHEREAS the Government further intends to appoint members of the Royal Commission on Electric Power Planning to the Environmental Assessment Board in order to transfer experience in electric power planning matters to that Board;

AND WHEREAS by Order-in-Council numbered OC-1999/78 dated the 5th day of July, 1978, the Committee of Council amended paragraph 4 of the Commission's terms of reference,

AND WHEREAS a paragraph was omitted from Order-in-Council numbered OC-1999/78, rendering it incomplete,

The Honourable the Provincial Secretary for Resources Development recommends that Order-in-Council numbered OC-1999/78 be revoked and that paragraph 4 of Order-in-Council numbered OC-2005B/75 be further amended as follows:

4.) A) Having concluded its hearings with respect to paragraphs 1, 2 and 3 of its terms of reference;

i) For the geographic area of Ontario south of Bruce nuclear power development and west of a line between Essa transformer station and Nanticoke generating station, consider and report to the Minister of Energy on or before May 31, 1979 on load growth in the area up to the end of 1987 and from 1987 to the year 2000, the capability of existing and committed bulk power generation and transmission facilities to supply this load to the area taking into account Government policy with respect to the use of interconnections with neighbouring utilities, and the resulting date at which additional bulk power facilities, if any, will be needed, but excluding consideration of the specific nature of the additional bulk power facilities which may be required and of their locational and environmental aspects; and

ii) For the geographic area of Ontario east of Lennox generating station, consider and report to the Minister of Energy on or before June 30, 1979 on load growth in the area up to the end of 1987 and from 1987 to the year 2000, the capability of existing and committed bulk power generation and transmission facilities to supply this load to the area taking into account Government policy with respect to the use of interconnections with neighbouring utilities, and the resulting date at which additional bulk power facilities, if any, will be needed, but excluding consideration of the specific nature of the additional bulk power facilities which may be re-required and of their locational and environmental aspects;

B) Provide the Government with its report and recommendations on paragraphs 1, 2 and 3 of these terms of reference on or before October 31, 1979.

The Committee of Council concur in the

recommendation of the Honourable the Provincial Secretary for Resources Development and advise that the same be acted on.

Certified,

Deputy Clerk, Executive Council.

APPENDIX B

Chapter III and Tables B-7 and B-8 from the SRI Report to CEA entitled "Long Range Electricity Forecast for Canada - A Methodology", dated November, 1978.

III MODEL RELATIONSHIPS

Four types of forecasting equations were developed: one for the industrial market, one for the residential and commercial markets, one for the farm sector, and one for competitive heating markets. These relationships along with general macroeconomic model relationships are discussed in Chapter III. The specific equations are listed in Appendix A. Descriptions of the various methods employed in the estimation of model parameters are detailed in Appendix B.

General Energy Growth and Market Share Model

This section serves as a discussion of the concepts and implementation of the model for all of the energy markets described in the study, except for the farm market, which has its own equation form. (Its form will be described later.) The general approach to describing total market growth will be outlined, followed by a discussion of exactly which variables control the model equation for each end-use market. This discussion will be referenced in each of the market sections that follow in Chapter IV of this report. In addition, for those markets in which electricity competes with other fuels, we discuss the methodology that connects market share and electricity demand.

In general terms, the model equation used in this study is as follows:

$$\text{(Demand in the next period)} =$$

$$\text{Constant} \times \text{(Demand in the current period)}^{\alpha} \times$$
$$\text{(Income in the next period)}^{A(1-\alpha)} \times$$
$$\text{(Price in the next period)}^{B(1-\alpha)} \; .$$

The first term in the form, the constant, is simply a statistical requirement for fitting historical data. In the actual implementation of the form, the constant is not relevant as a ratio form is used to force the model to extrapolate from the last year in the historical period. The ratio form has the following appearance:

$$\frac{\text{Demand in the next period}}{\text{Demand in the current period}} =$$

$$\left(\frac{\text{Demand in the current period}}{\text{Demand in the previous period}}\right)^{\alpha} \times$$

$$\left(\frac{\text{Income in the next period}}{\text{Income in the current period}}\right)^{A(1-\alpha)} \times$$

$$\left(\frac{\text{Price in the next period}}{\text{Price in the current period}}\right)^{B(1-\alpha)} .$$

The exponents of the ratio form are identical to the non-ratio form. The second term of the original form is the lag term, and the exponent α is the lag parameter. The interpretation of this parameter is that the next period depends to some extent on the current period. Another way to look at it is to consider there is a certain amount of inertia in each market. Regardless of the economic influences of the next period--the income and price terms--total market consumption can only increase or decrease so much. With appliances, for example, limited electricity distribution and possible limitations in the availability of appliances could hold down the growth of the market despite sharp increases in income and drops in electricity prices. The term α measures the magnitude of this inertia in each market. In one extreme case, $\alpha = 1$ means that the market is fixed at a constant value and is not sensitive at all to economic influences. In the other extreme case, $\alpha = 0$ means that there is no inertia and that the market depends only upon economic influences. Real-world situations, of course, fall between these two extremes.

Two energy markets represent the extremes of this lag and time response. In one extreme, manufacturing facilities, energy use tracks levels of plant production. In this case there is no time lag; therefore, the lag parameter is zero. Another case is the conversion of households to electric heating, a more slowly-moving market. The lag parameter would be more like 0.95, reflecting the 25 or more years required to convert all households. Table 5 lists values of the lag parameter and the corresponding time in years for an 80 percent change in the market in response to a given occurrence.

Table 5

RELATIONSHIP BETWEEN LAG PARAMETERS AND TIME

Lag Parameter	Time (years)
0.0	0.0
0.2	1.2
0.4	1.8
0.6	3.2
0.8	7.2
0.9	15.0

The third term stands for income, and reflects the notion that the more people make, the more energy they consume. There is, however, a saturation effect. People will keep their homes only so warm or buy only so many appliances, regardless of their income. Saturation terms can be explicitly included in the model, but limitations in the data, as well as a preference for simplicity, have led us not to do so. The system does allow for considering saturation effects through its ability to vary parameters with time throughout the forecast horizon.

The exponent of the income term is $A(1-\alpha)$, where A represents the long-term income elasticity, and the $(1-\alpha)$ adjusts for the lag parameter. Only $(1-\alpha)$ of the "frictionless" income effect will occur because of the inertia that is described by the lag term. The significance of income elasticity might be seen most easily in the ratio form. It measures how much of a relative change in energy consumption will result from a given

relative change in incomes. Typical values for A are about 0 to 0.2 for heating markets, about 0.9 to 1.2 for light manufacturing, and more than 1.0 for appliances and the commercial end uses.

The last term stands for price. B represents the price elasticity, and ($1-\alpha$) stands for the same lag adjustment as above. The same comments about saturation that were made previously also apply to the price term. The ratio form, given that B must be negative, shows that the price elasticity controls the relative market growth in response to a given relative reduction in price. The inverse effect of the elasticities also naturally applies; falling incomes and rising prices lead to shrinking markets.

Given the general form, it still remains to select exactly those variables that are to be used to model each market. The choices include the following:

- Total energy consumption (demand) or consumption (demand) per capita
- The measure of income most closely related to a given market
- The appropriate measure of price.

Table 6 shows the variables chosen to describe each energy market. The weighted average prices previously specified are calculated using the oil, gas, and electricity market shares and their respective prices. Although all prices are forecast, only electricity's market share is forecast for the competitive markets. The market shares of oil and gas in the base year are used for the purposes of calculating the weighted averages, both for the energy relationships and the market share projections. Trial calculations demonstrated that this simplification introduced negligible error into the results.

Farm Forecasting Relationship

The special equation for electrical energy consumption on farms is slightly different from the equations for the other market relationships. While more detailed work is needed on the agricultural sector, the relationship included in the model captures the following concepts of what controls the market:

Table 6

MODEL VARIABLES

Market	Energy Measure	Income Measure	Price Measure
Residential space heating	kWh/capita	Total GDPP/ capita	Weighted average residential energy price
Residential water heating	kWh/capita	Total GDPP/ capita	Weighted average residential energy price
Appliances	kWh/capita	Total GDPP/ capita	Residential electricity price
Commercial heating	kWh/service employee	Total GDPP/ capita	Weighted average residential energy price
Commercial motors	kWh/service employee	Total GDPP/ capita	Commercial electricity price
Street lighting	kWh	Total GDPP	Commercial electricity price
Light manufacturing	kWh	GDPP-Manufacturing	Industrial electricity price

- There is a lagged relationship between energy requirements and GDPP-Agriculture.
- There is a strong relationship between farm usage and general residential usage in the same period.

The following parameters are specified for the farm equation:

A: The GDPP-Agriculture elasticity

B: The total residential consumption electricity

C: The GDPP-Agriculture lag factor.

A specifies the relative growth of agricultural electricity demand compared to the growth in GDPP-Agriculture. B specifies the amount of relative growth dependent on residential demand growth. C is the familiar lag factor.

Industrial Forecasting Relationships

All of the industrial sector markets, except light manufacturing, are forecast using a straightforward approach. Electricity consumption for light manufacturing is forecast based on GDPP-Manufacturing and industrial price for electricity, as described previously. The rest of the markets are estimated as follows:

(1) The data for the base year of history are used to calculate the electricity consumption per unit of industrial output.

(2) The annual growth rate of industrial output, supplied by the user, is used to project the output.

(3) The parameter for annual efficiency improvement is used to reduce the expected electrical consumption per unit of output.

(4) The expected output is multiplied by the expected per unit consumption to yield total consumption by industry.

The annual efficiency improvement estimates should be based both on experience and on available technological forecasts. The form of the average improvement equation is:

$$\text{(Unit usage next period)} = \left[\frac{\text{(Units consumed during last period)}}{1 + \text{Efficiency improvement}}\right] .$$

Market Share Forecasts

The principal markets in which electricity competes with other sources of energy are the residential space heating, residential water heating, and commercial heating markets. For these markets, SRI's approach is first to estimate the total energy requirements and then to estimate the share of the market that will be captured by electricity.

The form of the market share model can be described in two parts. In the first stage,

(Market share in the next period) =
(Lag factor) x (Market share in the next period) +
(1 - lag factor) x (Expected market share) .

The lag factor has much the same significance here as it did in the energy equations: market share can change only so much from period to period because of lags in the economy. The expected market share indicates what the market share would be if there were no lags in the system, i.e., what share a given fuel--electricity in this case--would be based on theoretical economic considerations. Another way to look at market share would be to consider it as what the market share would be in many years if there were no changes in economic conditions.

The second stage, the long-term expected market share, is calculated as follows:

$$(\text{Expected market share})_e = \frac{(\text{Maximum market share})}{\left(1 + P_R^N\right)}$$

$$\text{where } P_R = \frac{(\text{Price}_e)\ (\text{Efficiency})}{\left(\text{Price}_{avg}\right)} .$$

The maximum market share term is included for situations when it is known that, for other reasons--distribution problems, for example--a given fuel will never capture all of a market regardless of the price incentives. The form of the equation is such that even if the price of the fuel in question reaches zero, the resulting market share will never rise above the maximum market share.

The term $\frac{\text{Price}_e}{\text{Price}_{avg}}$ measures the relative price incentive of using electricity. Price_{avg} is the average price of competing fuels, weighted by market share. For a given set of parameters, it can be seen as Price_e, the price of electricity drops, the resulting market share approaches the maximum market share.

The efficiency parameter provides for the adjustment of the results to account for such differences as the capital requirements needed to convert from one fuel to another, and societal or consumer preferences for one fuel versus another. One way to develop a fuel efficiency value

is to consider a price ratio that, all things considered, would lead to a fuel's capturing half of the maximum market share.

GDPP and Population Forecasts

Two key parameters that are supplied by the user are the growth rates for GDPP and GDPP per capita. The specifications of these two rates imply a growth rate for population that is calculated by the system. It would have been possible to input any two of these three growth rates and calculate the third. Total GDPP and GDPP per capita were chosen because the first reflects total growth in the provincial economy and the second suggests individual economic well-being. The calculated population growth rate, meanwhile, is the maximum sustainable growth rate consistent with the projected gains in economic activity and improvements in the standard of living.

It has been shown that several other key macroeconomic variables can be projected based on these growth rates. (Examples are included in the statistical summary in Appendix B). The method used in this system is to specify the relationship--a kind of elasticity--between the controlling growth rate and the dependent growth rate. Five such elasticities are used in the system:

(1) GDPP-Manufacturing, based on total GDPP
(2) GDPP-Agriculture, based on total GDPP
(3) Total employment, based on population
(4) Service employment, based on population
(5) Number of households, based on population.

In Ontario, for example, the elasticity of service employment with population was specified as 2.4 in 1976, dropping to 2.2 in 1990. That means that service employment is expected to grow 2.4 times as fast as population, dropping to 2.2 times as fast later. These variables, with the exception of number of households and total employment which are calculated for informational purposes, are used in subsequent calculations. The number for service employment, for example, is used to derive the data on energy consumption per service employee; this input is used in

the models that deal with electricity use for motor drives and heating in the commercial market.

TABLE B-7
FORECAST MARKET SHARE AND PRICE PARAMETERS

MARKET SHARE MODEL	ONTARIO 1976	1990
RESIDENTIAL SPACE MEETING		
Lag Parameter	.91	.91
Max. Share	100.0	100.0
Relative El. Efficiency	50.0	50.0
Price Ratio Power	2.83	2.83
RESIDENTIAL WATER HEATING		
Lag Parameter	.80	.80
Max. Share	100.0	100.0
Relative El. Efficiency	80.0	80.0
Price Ratio	.10	.10
COMMERCIAL SPACE HEATING		
Lag Parameter	.95	.95
Max. Share	100.0	100.0
Relative El. Efficiency	50.00	50.00
Price Ratio Power	2.00	2.00
PRICE GROWTH RATES REAL		
Residential		
Electricity	1.00	1.00
Gas	2.00	2.00
Oil	0.00	2.00
Commercial		
Electricity	2.00	1.00
Gas	3.00	2.00
Oil	0.00	2.00
Industrial		
Electricity	2.00	1.00

TABLE B-8
REFERENCE CASE FORECAST
MACROECONOMIC AND INDUSTRIAL PARAMETERS

MACRO GROWTH RATES	ONTARIO 1976	1990
GDPP	3.8	3.2
GDPP/Capita	2.4	2.0
Population	1.4	1.2
CPI Percent/Year	6.0	4.0
ELASTICITIES		
GDPP Mfg./GDPP	.90	.85
GDPP Ag./GDPP	.40	.40
Total Employment/Pop.	1.8	1.4
Serv. Employment/Pop.	2.4	2.2
Households/Pop.	1.8	1.6
INDUSTRIAL GROWTH RATES		
Aluminum	3.5	2.5
Pulp & Paper	3.0	2.0
Chemicals	4.5	3.5
Steel	3.0	2.5
INDUSTRIAL EFFICIENCY IMPROVEMENTS PERCENT/YR.		
Aluminum	.50	.50
Pulp & Paper	.50	.50
Chemicals	.50	.50
Steel	.50	.50
MINING GROWTH RATES		
Iron Ore	3.0	2.5
Copper	3.0	2.0
Coal	6.0	3.0
Other	5.0	4.0
MINING EFFICIENCY IMPROVEMENTS		
Iron Ore	0.0	0.0
Copper	0.0	0.0
Coal	0.0	0.0
Other	0.0	0.0
LOSSES AND EXPORTS	9.60	9.60

APPENDIX C

Results from SRI-CEA Model Study in which the Growth Rates of Gross Domestic Provincial Product were varied.

SOUTHWESTERN ONTARIO
FORECAST OF ELECTRIC ENERGY CONSUMPTION
USING SRI-CEA ECONOMETRIC MODEL

SCENARIO 1

BASIS: All Parameters Including GDPP as in SRI-CEA Model Reference Forecast

	ELECTRIC ENERGY CONSUMPTION (GW·h)					
	Actual	Forecast				
	1976	1980	1985	1990	1995	2000
RESIDENTIAL (GW·h)						
SPACE HEATING	1055	1714	2370	2907	3427	4013
WATER HEATING	1343	1479	1619	1749	1864	1985
APPLIANCES ETC.	2464	2946	3641	4454	5165	5986
TOTAL RESIDENTIAL ELECTRICITY	4862	6139	7630	9110	10456	11984
TOTAL FARM (GW·h)	1074	1318	1604	1890	2150	2445
COMMERCIAL (GW·h)						
HEATING	118	631	1306	2049	2847	3773
OTHER (MOTORS + LIGHTING)	2028	2575	3461	4488	5467	6658
STREET LIGHTING	158	187	229	278	323	374
TOTAL COMMERCIAL ELECTRICITY	2304	3393	4996	6815	8637	10804
MANUFACTURING (GW·h)						
CHEMICALS	1149	1343	1633	1965	2277	2637
STEEL	9	10	11	13	14	15
LIGHT MANUFACTURING	6446	7356	8677	10152	11495	13015
SUBTOTAL – MANUFACTURING	7604	8710	10321	12130	13786	15668
MINING (GW·h)	0	0	0	0	0	0
TOTAL CONSUMPTION (GW·h)	15844	19559	24551	29944	35029	40901

SOUTHWESTERN ONTARIO
FORECAST OF ELECTRIC ENERGY CONSUMPTION
USING SRI-CEA ECONOMETRIC MODEL

SCENARIO 2

BASIS: Growth Rates in GDPP as per Ontario Economic Council:
All Other Parameters as in Scenario 1.

	ELECTRIC ENERGY CONSUMPTION (GW·h)					
	Actual	Forecast				
	1976	1980	1985	1990	1995	2000
RESIDENTIAL (GW·h)						
SPACE HEATING	1055	1816	2605	3261	4015	4910
WATER HEATING	1343	1566	1779	1962	2185	2429
APPLIANCES ETC.	2464	3120	4004	4997	6051	7324
TOTAL RESIDENTIAL ELECTRICITY	4862	6501	8388	10220	12251	14664
TOTAL FARM (GW·h)	1074	1390	1751	2101	2489	2945
COMMERCIAL (GW·h)						
HEATING	118	722	1630	2677	4086	5945
OTHER (MOTORS + LIGHTING)	2028	2944	4319	5863	7845	10492
STREET LIGHTING	158	199	256	318	386	467
TOTAL COMMERCIAL ELECTRICITY	2304	3865	6205	8858	12316	16904
MANUFACTURING (GW·h)						
CHEMICALS	1149	1343	1633	1965	2277	2637
STEEL	9	10	11	13	14	15
LIGHT MANUFACTURING	6446	7788	9535	11368	13358	15697
SUBTOTAL – MANUFACTURING	7604	9142	11179	13346	15649	18350
MINING (GW·h)	0	0	0	0	0	0
TOTAL CONSUMPTION (GW·h)	15844	20897	27523	34526	42705	52863

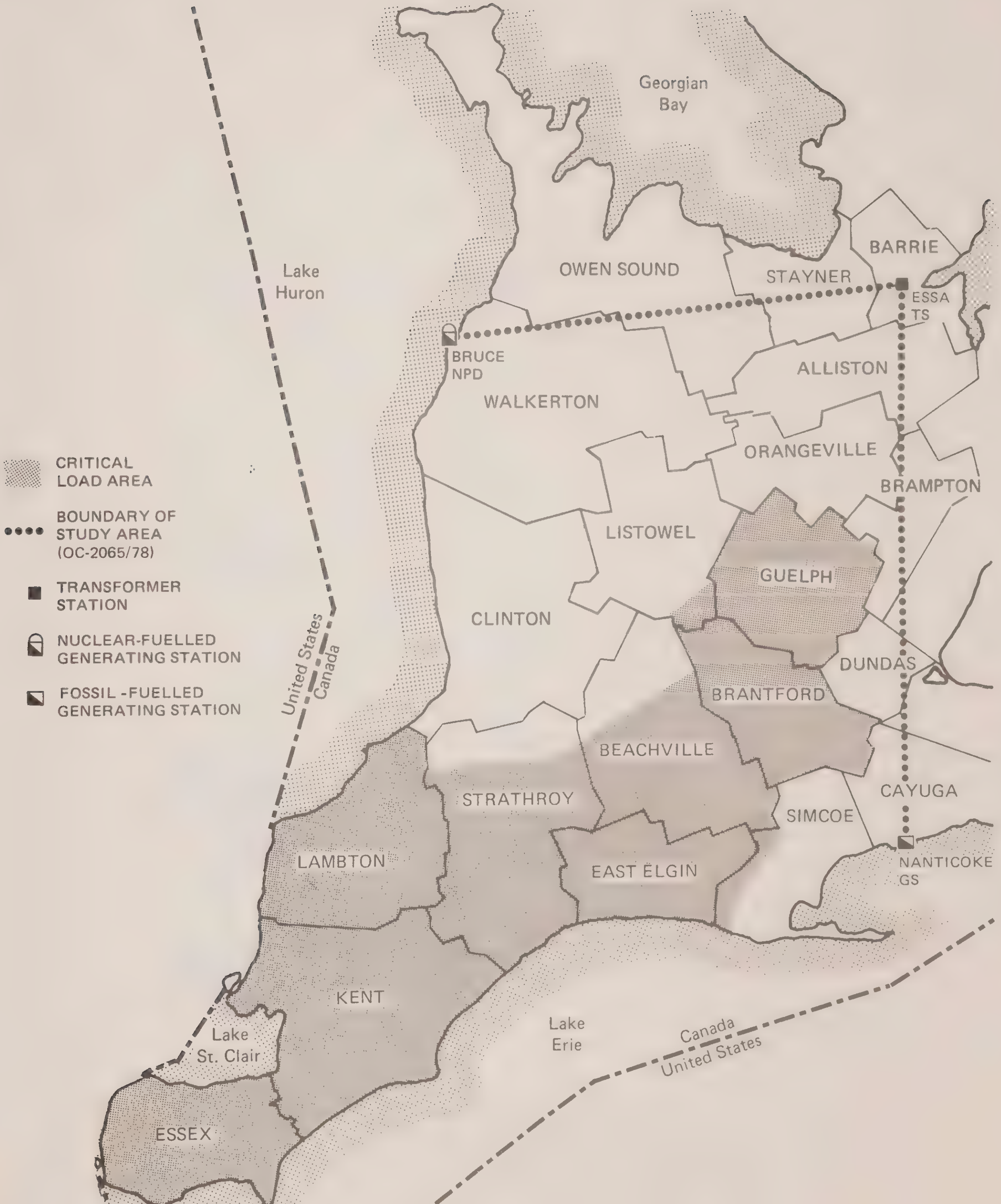
APPENDIX C-2

SOUTHWESTERN ONTARIO
FORECAST OF ELECTRIC ENERGY CONSUMPTION
USING SRI-CEA ECONOMETRIC MODEL

SCENARIO 3

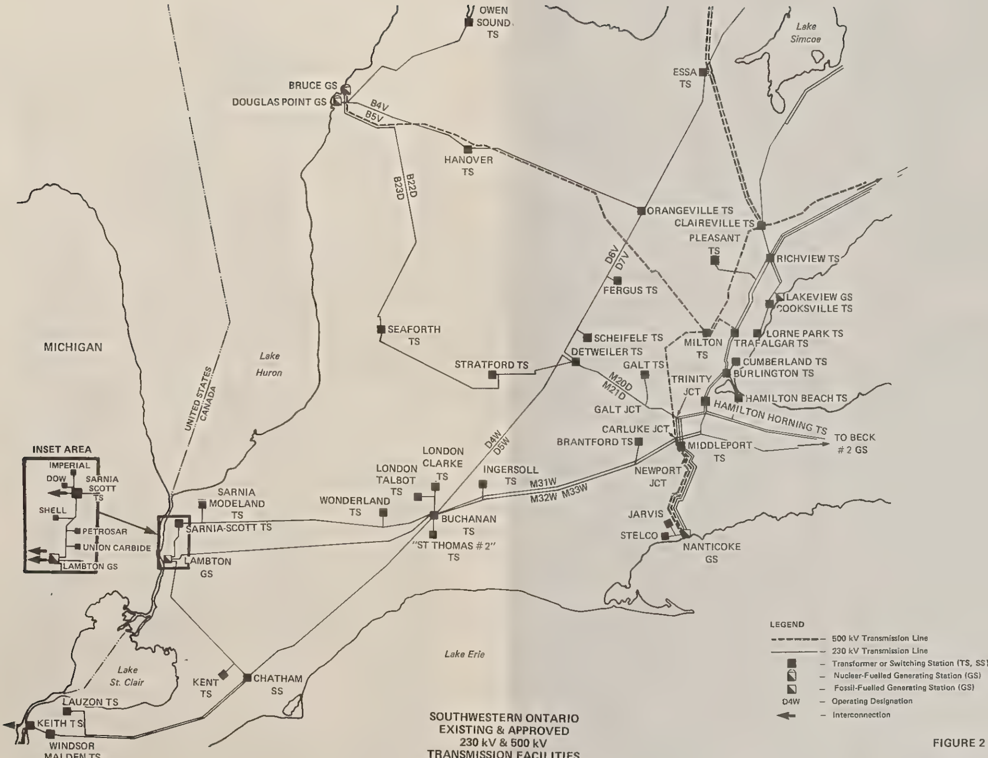
BASIS: High Growth Rates in GDPP; All Other Parameters as in Scenario 1.

	ELECTRIC ENERGY CONSUMPTION (GW·h)					
	Actual	Forecast				
	1976	1980	1985	1990	1995	2000
RESIDENTIAL (GW·h)						
SPACE HEATING	1055	1830	2743	3500	4392	5476
WATER HEATING	1343	1578	1873	2106	2390	2709
APPLIANCES ETC.	2464	3143	4215	5362	6620	8167
TOTAL RESIDENTIAL ELECTRICITY	4862	6551	8831	10968	13401	16352
TOTAL FARM (GW·h)	1074	1399	1836	2243	2704	3257
COMMERCIAL (GW·h)						
HEATING	118	735	1836	3152	5012	7600
OTHER (MOTORS + LIGHTING)	2028	2996	4865	6904	9624	13412
STREET LIGHTING	158	201	272	346	427	527
TOTAL COMMERCIAL ELECTRICITY	2304	3931	6973	10401	15064	21538
INDUSTRIAL						
MANUFACTURING (GW·h)						
CHEMICALS	1149	1343	1633	1965	2277	2637
STEEL	9	10	11	13	14	15
LIGHT MANUFACTURING	6446	7847	10035	12189	14559	17391
SUBTOTAL – MANUFACTURING	7604	9201	11679	14167	16850	20044
MINING (GW·h)	0	0	0	0	0	0
TOTAL CONSUMPTION (GW·h)	15844	21082	29319	37778	48019	61191



SOUTHWESTERN ONTARIO
OPERATING AND LOAD AREAS

FIGURE 1



SOUTHWESTERN ONTARIO
EXISTING & APPROVED
230 kV & 500 kV
TRANSMISSION FACILITIES

FIGURE 2

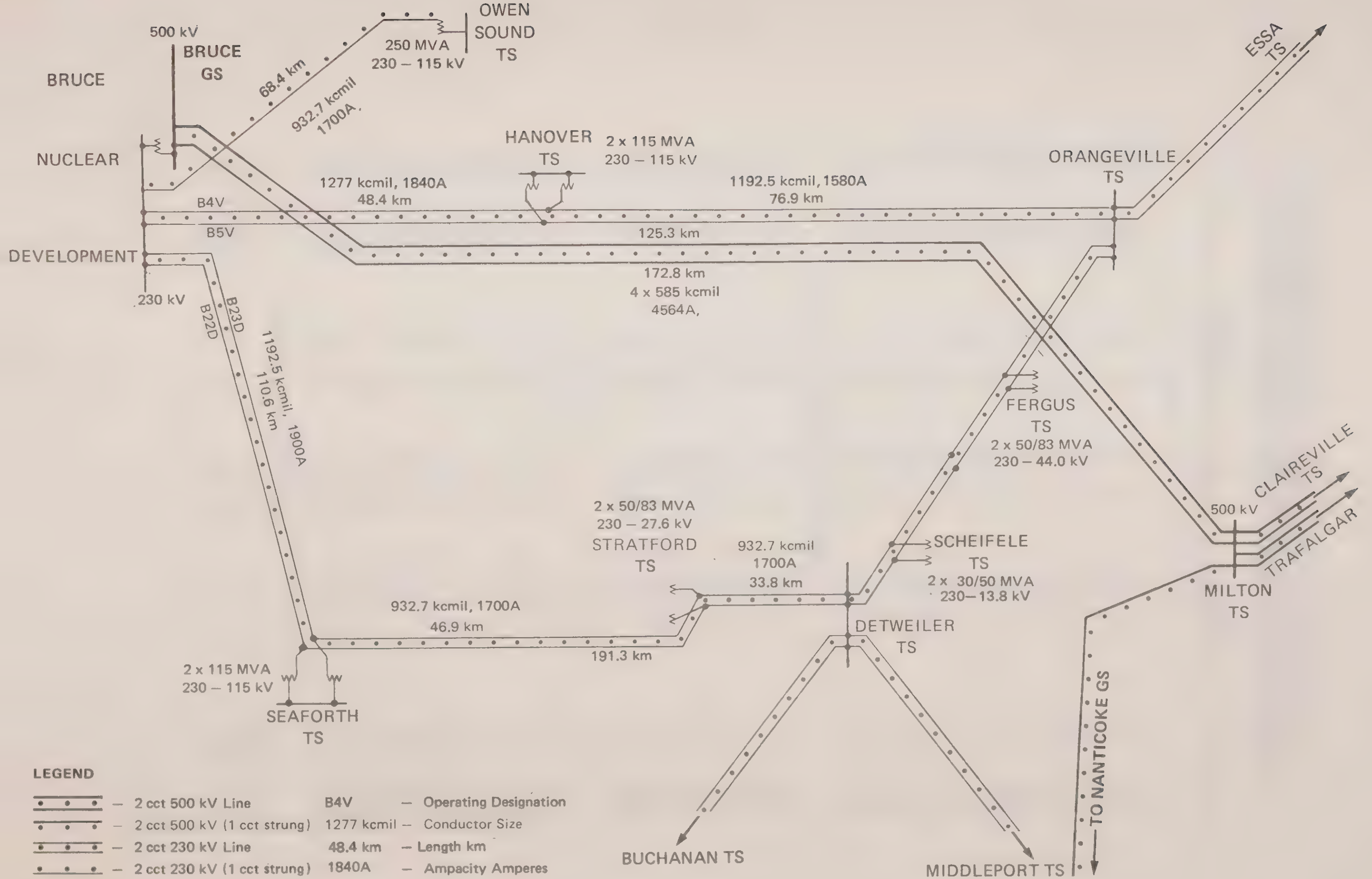


FIGURE 3

TECHNICAL DETAILS OF EXISTING AND APPROVED FACILITIES FOR INCORPORATION OF BRUCE GS 'A'

FIGURE 3

ESSEX OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	141	30	0	171
1963	150	32	0	182
1964	161	34	0	195
1965	188	30	0	218
1966	231	31	0	262
1967	223	33	0	256
1968	247	43	0	290
1969	259	46	0	305
1970	286	52	0	338
1971	301	53	0	354
1972	325	61	0	386
1973	333	69	0	402
1974	338	75	0	413
1975	371	80	0	451
1976	388	91	0	479
1977	387	92	0	479
	LOAD FORECAST REPORT – 780213			
1978	429	89	0	518
1979	452	94	0	546
1980	472	101	0	573
1981	493	108	0	601
1982	515	115	0	630
1983	538	124	0	662
1984	566	132	0	698
1985	594	142	0	736
1986	625	151	0	776
1987	656	162	0	818
		PROJECTION		
1988	690	176	0	866
1989	725	192	0	917
1990	761	209	0	970
1991	799	227	0	1026
1992	837	247	0	1084
1993	876	268	0	1144
1994	916	290	0	1206
1995	957	313	0	1270
1996	998	338	0	1336
1997	1041	364	0	1405
1998	1084	392	0	1476
1999	1128	421	0	1549
2000	1173	452	0	1625
		GROWTH RATE – PERCENT		
1962 – 1977	7.0	7.8	–	7.1
1977 – 1987	5.4	5.8	–	5.5
1987 – 2000	4.6	8.2	–	5.4

FIGURE 4A

KENT OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	48	9	0	57
1963	52	10	0	62
1964	57	11	0	68
1965	65	25	0	90
1966	70	25	0	95
1967	72	27	0	99
1968	76	32	0	108
1969	79	34	0	113
1970	78	36	0	114
1971	83	36	0	119
1972	90	43	0	133
1973	95	43	0	138
1974	95	44	0	139
1975	101	50	0	151
1976	109	54	0	163
1977	110	55	0	165
		LOAD FORECAST REPORT – 780213		
1978	113	58	0	171
1979	118	61	0	179
1980	124	66	0	190
1981	131	72	0	203
1982	137	78	0	215
1983	145	85	0	230
1984	153	91	0	244
1985	161	98	0	259
1986	170	106	0	276
1987	179	114	0	293
		PROJECTION		
1988	190	124	0	314
1989	200	134	0	334
1990	212	146	0	358
1991	224	158	0	382
1992	236	171	0	407
1993	249	185	0	434
1994	262	200	0	462
1995	276	215	0	491
1996	290	232	0	522
1997	304	250	0	554
1998	320	270	0	590
1999	335	290	0	625
2000	351	312	0	663
		GROWTH RATE – PERCENT		
1962 – 1977	5.7	12.8	–	7.3
1977 – 1987	5.0	7.6	–	5.9
1987 – 2000	5.3	8.1	–	6.5

FIGURE 4B

LAMBTON OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	15	0	126	141
1963	16	0	109	125
1964	17	0	106	123
1965	18	27	109	154
1966	19	29	167	215
1967	76	32	184	292
1968	80	36	212	328
1969	87	38	229	354
1970	84	46	239	369
1971	86	47	239	372
1972	92	55	189	336
1973	96	56	184	336
1974	101	59	146	306
1975	112	63	177	352
1976	116	71	169	356
1977	124	68	190	382
		LOAD FORECAST REPORT – 780213		
1978	120	82	207	409
1979	123	90	227	440
1980	129	98	241	468
1981	136	107	245	488
1982	144	116	264	524
1983	152	126	293	571
1984	160	138	307	605
1985	168	151	322	641
1986	177	164	338	679
1987	186	179	354	719
		PROJECTION		
1988	195	194	366	755
1989	204	209	379	792
1990	213	225	392	830
1991	222	242	406	870
1992	232	260	420	912
1993	241	279	435	955
1994	251	299	450	1000
1995	262	321	466	1049
1996	272	344	482	1098
1997	283	368	499	1150
1998	295	393	517	1205
1999	306	421	535	1262
2000	318	450	554	1322
		GROWTH RATE – PERCENT		
1962 – 1977	15.1	–	2.8	6.9
1977 – 1987	4.1	10.2	6.4	6.5
1987 – 2002	4.2	7.3	3.5	4.8

FIGURE 4C

STRATHROY OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	163	21	0	184
1963	181	23	0	204
1964	195	26	0	221
1965	208	30	0	238
1966	221	35	0	256
1967	211	36	0	247
1968	233	33	0	266
1969	241	35	0	276
1970	252	39	0	291
1971	266	40	0	306
1972	302	46	0	348
1973	313	53	0	366
1974	332	46	4	382
1975	344	54	4	402
1976	350	59	5	414
1977	350	61	5	416
		LOAD FORECAST REPORT – 780213		
1978	363	64	3	430
1979	373	68	3	444
1980	386	72	3	461
1981	402	77	3	482
1982	423	81	3	507
1983	441	86	3	530
1984	460	91	3	554
1985	480	97	3	580
1986	501	102	3	606
1987	523	108	3	634
		PROJECTION		
1988	548	116	3	667
1989	574	124	4	702
1990	602	133	4	739
1991	630	142	4	776
1992	660	152	5	817
1993	691	162	5	858
1994	723	172	5	900
1995	757	184	6	947
1996	792	196	6	994
1997	829	208	7	1044
1998	867	222	7	1096
1999	907	236	7	1150
2000	948	251	8	1207
		GROWTH RATE – PERCENT		
1962 – 1977	5.2	7.4	–	5.6
1977 – 1987	4.1	5.9	–	4.3
1987 – 2000	4.7	6.7	7.8	5.1

FIGURE 4D

EAST ELGIN OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	36	24	0	60
1963	41	27	0	68
1964	45	30	0	75
1965	47	23	0	70
1966	48	25	0	73
1967	45	25	13	83
1968	50	28	16	94
1969	51	31	16	98
1970	52	33	14	99
1971	54	34	14	102
1972	59	37	14	110
1973	62	37	14	113
1974	65	37	14	116
1975	67	41	12	120
1976	71	40	13	124
1977	75	45	13	133
		LOAD FORECAST REPORT – 780213		
1978	77	45	12	134
1979	80	47	13	140
1980	84	50	13	147
1981	88	52	13	153
1982	93	55	14	162
1983	98	58	14	170
1984	104	61	13	178
1985	109	64	13	186
1986	115	68	12	195
1987	121	71	12	204
		PROJECT		
1988	128	75	14	217
1989	134	79	15	228
1990	141	83	17	241
1991	148	88	19	255
1992	156	92	20	268
1993	164	97	22	283
1994	172	102	24	298
1995	181	108	25	314
1996	190	113	27	330
1997	200	119	29	348
1998	210	126	30	366
1999	221	132	32	385
2000	232	139	33	404
		GROWTH RATE – PERCENT		
1962 – 1977	5.0	4.3	–	5.5
1977 – 1987	4.9	4.7	–	4.4
1987 – 2000	5.1	5.3	8.1	5.4

FIGURE 4E

BEACHVILLE OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	61	36	0	97
1963	66	39	0	105
1964	70	43	0	113
1965	79	33	39	151
1966	89	36	4	129
1967	85	35	13	133
1968	92	42	16	150
1969	94	46	12	152
1970	97	50	11	158
1971	101	52	11	164
1972	112	56	13	181
1973	117	61	14	192
1974	117	64	14	195
1975	121	72	14	207
1976	130	80	13	223
1977	131	80	12	223
		LOAD FORECAST REPORT – 780213		
1978	132	86	13	231
1979	136	92	14	242
1980	142	99	15	256
1981	148	106	15	269
1982	155	113	15	283
1983	162	121	15	298
1984	169	129	15	313
1985	177	138	14	329
1986	185	148	13	346
1987	194	158	13	365
		PROJECTION		
1988	204	168	15	387
1989	214	179	17	410
1990	225	190	18	433
1991	236	201	20	457
1992	248	214	22	484
1993	260	227	24	511
1994	272	241	26	539
1995	285	256	28	569
1996	298	272	29	599
1997	311	288	31	630
1998	324	306	33	663
1999	338	325	34	697
2000	352	345	36	733
		GROWTH RATE – PERCENT		
1962 – 1977	5.2	5.5	–	5.7
1977 – 1987	4.0	7.0	0.8	5.1
1987 – 2000	4.7	6.2	6.4	5.5

FIGURE 4F

CLINTON OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	24	26	0	50
1963	24	28	0	52
1964	26	30	0	56
1965	27	23	0	50
1966	27	23	0	50
1967	26	28	0	54
1968	28	33	0	61
1969	29	36	0	65
1970	30	40	0	70
1971	32	41	0	73
1972	34	46	0	80
1973	37	48	0	85
1974	38	44	3	85
1975	43	50	3	96
1976	44	58	3	105
1977	44	59	3	106
	LOAD FORECAST REPORT – 780213			
1978	45	60	3	108
1979	46	64	3	113
1980	49	69	3	121
1981	51	74	3	128
1982	54	80	3	137
1983	56	86	3	145
1984	59	93	3	155
1985	62	100	3	165
1986	65	108	3	176
1987	69	116	3	188
		PROJECTION		
1988	72	123	3	198
1989	75	130	3	208
1990	79	138	4	221
1991	83	146	4	233
1992	87	155	4	246
1993	91	164	5	260
1994	95	174	5	274
1995	100	184	5	289
1996	105	195	6	306
1997	110	206	6	322
1998	115	218	7	340
1999	121	230	7	358
2000	126	244	7	377
		GROWTH RATE – PERCENT		
1962 – 1977	4.1	5.6	–	5.1
1977 – 1987	4.6	7.0	0.0	5.9
1987 – 2000	4.7	5.9	6.7	5.5

FIGURE 4G

BRANTFORD OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	63	11	0	74
1963	68	11	0	79
1964	75	12	0	87
1965	85	28	0	113
1966	91	25	0	116
1967	91	24	0	115
1968	98	28	0	126
1969	100	28	0	128
1970	109	35	0	144
1971	114	32	0	146
1972	125	36	0	161
1973	135	38	0	173
1974	134	41	0	175
1975	138	36	0	174
1976	151	39	0	190
1977	151	39	0	190
		LOAD FORECAST REPORT – 780213		
1978	153	29	0	182
1979	168	31	0	199
1980	178	32	0	210
1981	190	34	0	224
1982	202	36	0	238
1983	215	37	0	252
1984	232	40	0	272
1985	250	42	0	292
1986	269	44	0	313
1987	290	47	0	337
		PROJECTION		
1988	305	49	0	354
1989	321	52	0	373
1990	337	55	0	392
1991	354	57	0	411
1992	370	60	0	430
1993	387	63	0	450
1994	404	66	0	470
1995	421	69	0	490
1996	439	72	0	511
1997	456	75	0	531
1998	473	78	0	551
1999	490	81	0	571
2000	507	85	0	592
		GROWTH RATES – PERCENT		
1962 – 1977	6.0	8.8	–	6.5
1977 – 1987	6.7	1.9	–	5.9
1987 – 2000	4.4	4.7	–	4.4

FIGURE 4H

GUELPH OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	193	13	0	206
1963	206	14	0	220
1964	228	17	0	245
1965	254	32	4	290
1966	296	32	4	332
1967	315	31	4	350
1968	354	35	4	393
1969	382	36	4	422
1970	399	39	3	441
1971	423	40	4	467
1972	471	44	5	520
1973	501	48	5	554
1974	516	49	5	570
1975	538	60	5	603
1976	573	61	5	639
1977	584	66	5	655
		LOAD FORECAST REPORT – 780213		
1978	652	33	7	692
1979	681	36	9	726
1980	716	38	9	763
1981	755	42	10	807
1982	794	45	10	849
1983	843	49	11	903
1984	893	53	12	958
1985	946	58	13	1017
1986	1002	63	13	1078
1987	1061	69	14	1144
		PROJECTION		
1988	1117	73	15	1205
1989	1177	77	15	1269
1990	1239	81	16	1336
1991	1305	85	16	1406
1992	1374	90	17	1481
1993	1447	94	17	1558
1994	1523	99	18	1640
1995	1604	104	19	1727
1996	1688	110	19	1817
1997	1777	115	20	1912
1998	1871	121	20	2012
1999	1970	127	21	2118
2000	2074	133	21	2228
		GROWTH RATES – PERCENT		
1962 – 1977	7.7	11.4	–	8.0
1977 – 1987	6.2	0.4	10.8	5.7
1987 – 2000	5.3	5.2	3.2	5.3

FIGURE 4I

LISTOWEL OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	9	10	0	19
1963	10	11	0	21
1964	11	14	0	25
1965	12	14	0	26
1966	12	18	0	30
1967	13	20	0	33
1968	14	21	0	35
1969	15	22	0	37
1970	16	24	0	40
1971	16	26	0	42
1972	17	29	0	46
1973	18	30	0	48
1974	20	26	0	46
1975	22	33	0	55
1976	23	37	0	60
1977	24	35	0	59
		LOAD FORECAST REPORT – 780213		
1978	22	36	0	58
1979	22	37	0	59
1980	23	39	0	62
1981	25	41	0	66
1982	26	43	0	69
1983	27	45	0	72
1984	29	48	0	77
1985	30	51	0	81
1986	32	54	0	86
1987	33	57	0	90
		PROJECTION		
1988	35	59	0	94
1989	36	62	0	98
1990	38	64	0	102
1991	40	67	0	107
1992	42	70	0	112
1993	43	73	0	116
1994	45	76	0	121
1995	47	79	0	126
1996	50	83	0	133
1997	52	86	0	138
1998	54	89	0	143
1999	57	93	0	150
2000	59	97	0	156
		GROWTH RATES – PERCENT		
1962 – 1977	6.8	8.7	–	7.8
1977 – 1987	3.2	5.0	–	4.3
1987 – 2000	4.6	4.2	–	4.3

FIGURE 4J

WALKERTON OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
1962	22	9	0	31
1963	25	11	0	36
1964	28	12	0	40
1965	29	23	0	52
1966	32	31	0	63
1967	32	28	0	60
1968	37	34	0	71
1969	38	35	0	73
1970	41	39	0	80
1971	43	43	3	89
1972	46	54	31	131
1973	49	55	63	167
1974	53	55	67	175
1975	59	75	67	201
1976	66	77	65	208
1977	67	76	65	208
	LOAD FORECAST REPORT – 780213			
1978	68	87	141	296
1979	72	89	201	362
1980	78	93	215	386
1981	84	98	215	397
1982	91	95	215	401
1983	98	102	215	415
1984	106	107	215	428
1985	115	113	215	443
1986	124	119	215	458
1987	135	125	215	475
	PROJECTION			
1988	144	134	217	495
1989	153	143	218	514
1990	162	153	219	534
1991	172	163	219	554
1992	183	174	220	577
1993	194	186	221	601
1994	205	198	221	624
1995	217	211	221	649
1996	230	225	221	676
1997	243	240	221	704
1998	257	255	221	733
1999	271	272	221	764
2000	286	289	221	796
	GROWTH RATES – PERCENT			
1962 – 1977	7.7	15.3	–	13.5
1977 – 1987	7.3	5.1	12.7	8.6
1987 – 2000	5.9	6.7	0.2	4.1

FIGURE 4K

ORANGEVILLE OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	6	8	0	14
1963	7	8	0	15
1964	7	9	0	16
1965	8	12	0	20
1966	9	13	0	22
1967	9	16	0	25
1968	11	18	0	29
1969	14	21	0	35
1970	15	22	0	37
1971	15	24	0	39
1972	17	27	0	44
1973	19	30	0	49
1974	20	30	0	50
1975	22	37	0	59
1976	23	45	0	68
1977	25	39	0	64
		LOAD FORECAST REPORT – 780213		
1978	28	48	0	76
1979	30	54	0	84
1980	32	61	0	93
1981	35	69	0	104
1982	38	78	0	116
1983	41	88	0	129
1984	44	100	0	144
1985	47	112	0	159
1986	51	127	0	178
1987	55	144	0	199
		PROJECTION		
1988	59	155	0	214
1989	63	167	0	230
1990	67	179	0	246
1991	71	193	0	264
1992	76	207	0	283
1993	80	223	0	303
1994	85	239	0	324
1995	90	257	0	347
1996	96	276	0	372
1997	101	295	0	396
1998	107	317	0	424
1999	113	339	0	452
2000	119	363	0	482
		GROWTH RATES – PERCENT		
1962 – 1977	10.0	11.1	–	10.7
1977 – 1987	8.2	14.0	–	12.0
1987 – 2000	6.1	7.4	–	7.0

FIGURE 4L

ALLISTON OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	8	11	0	19
1963	9	12	0	21
1964	10	13	0	23
1965	10	11	0	21
1966	11	12	0	23
1967	12	14	0	26
1968	13	16	0	29
1969	15	18	0	33
1970	16	21	0	37
1971	17	23	0	40
1972	19	26	0	45
1973	21	30	0	51
1974	22	30	0	52
1975	26	35	0	61
1976	28	40	0	68
1977	29	38	0	67
		LOAD FORECAST REPORT 780213		
1978	31	45	0	76
1979	34	47	0	81
1980	37	48	0	85
1981	40	50	0	90
1982	44	53	0	97
1983	48	57	0	105
1984	53	60	0	113
1985	58	62	0	120
1986	63	65	0	128
1987	69	68	0	137
		PROJECTION		
1988	74	73	0	147
1989	80	79	0	159
1990	87	85	0	172
1991	93	91	0	184
1992	101	97	0	198
1993	108	105	0	213
1994	117	112	0	229
1995	125	120	0	245
1996	134	129	0	263
1997	144	138	0	282
1998	154	148	0	302
1999	165	159	0	324
2000	176	170	0	346
		GROWTH RATES – PERCENT		
1962 – 1977	9.0	8.6	–	8.8
1977 – 1987	9.1	6.0	–	7.4
1987 – 2000	7.5	7.3	–	7.4

FIGURE 4M

OWEN SOUND OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	22	12	11	45
1963	24	14	9	47
1964	25	15	5	45
1965	27	16	7	50
1966	31	18	6	55
1967	35	21	4	60
1968	40	26	4	70
1969	42	29	4	75
1970	45	34	3	82
1971	46	38	3	87
1972	51	43	3	97
1973	57	47	3	107
1974	58	51	3	112
1975	69	59	3	131
1976	74	70	3	147
1977	73	67	3	143
		LOAD FORECAST REPORT – 780213		
1978	78	73	3	154
1979	82	81	3	166
1980	87	91	3	181
1981	94	102	3	199
1982	100	115	3	218
1983	107	129	3	239
1984	114	144	3	261
1985	122	162	3	287
1986	131	181	3	315
1987	141	203	3	347
		PROJECTION		
1988	151	219	3	373
1989	162	236	3	401
1990	174	255	3	432
1991	186	274	3	463
1992	199	296	3	498
1993	213	319	3	535
1994	228	344	3	575
1995	243	371	3	617
1996	259	399	3	661
1997	276	431	3	710
1998	294	464	3	761
1999	312	500	3	815
2000	332	539	3	874
		GROWTH RATES – PERCENT		
1962 – 1977	8.3	12.1	–	8.0
1977 – 1987	6.8	11.7	–	9.3
1987 – 2000	6.8	7.8	–	7.4

FIGURE 4N

SIMCOE OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
1962	17	15	0	32
1963	17	14	0	31
1964	20	16	0	36
1965	20	15	0	35
1966	21	15	0	36
1967	22	16	0	38
1968	25	19	0	44
1969	25	20	0	45
1970	27	21	0	48
1971	27	20	0	47
1972	30	23	0	53
1973	31	24	0	55
1974	34	27	0	61
1975	35	28	0	63
1976	37	29	0	66
1977	38	29	0	67
		LOAD FORECAST REPORT 780213		
1978	38	30	0	68
1979	39	32	0	71
1980	40	33	0	73
1981	43	34	0	77
1982	45	35	0	80
1983	47	36	0	83
1984	49	37	0	86
1985	51	39	0	90
1986	54	41	0	95
1987	56	43	0	99
		PROJECTION		
1988	59	45	0	104
1989	61	47	0	108
1990	64	49	0	113
1991	67	52	0	119
1992	70	54	0	124
1993	73	57	0	130
1994	76	60	0	136
1995	80	63	0	143
1996	83	66	0	149
1997	87	69	0	156
1998	91	73	0	164
1999	95	76	0	171
2000	99	80	0	179
		GROWTH RATES – PERCENT		
1967 – 1977	5.5	4.5	–	5.0
1977 – 1987	4.0	4.0	–	4.0
1987 – 2000	4.5	4.9	–	4.7

FIGURE 40

STAYNER OPERATING AREA ACTUAL & FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION (MW)

YEAR	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	10	8	0	18
1963	11	9	0	20
1964	12	10	0	22
1965	13	8	0	21
1966	14	9	0	23
1967	16	12	0	28
1968	21	14	0	35
1969	22	19	0	41
1970	23	23	0	46
1971	25	25	0	50
1972	29	29	0	58
1973	32	31	0	63
1974	32	31	0	63
1975	36	38	0	74
1976	51	34	0	85
1977	50	33	0	83
		LOAD FORECAST REPORT – 780213		
1978	53	31	0	84
1979	56	34	0	90
1980	60	38	0	98
1981	63	42	0	105
1982	68	46	0	114
1983	72	50	0	122
1984	76	56	0	132
1985	80	61	0	141
1986	85	67	0	152
1987	90	74	0	164
		PROJECTION		
1988	96	80	0	176
1989	103	86	0	189
1990	110	93	0	203
1991	117	100	0	217
1992	125	107	0	232
1993	133	115	0	248
1994	141	124	0	265
1995	150	133	0	283
1996	159	143	0	302
1997	168	153	0	321
1998	178	164	0	342
1999	188	176	0	364
2000	199	188	0	387
		GROWTH RATES – PERCENT		
1962 – 1977	11.3	9.9	–	10.7
1977 – 1987	6.1	8.4	–	7.0
1987 – 2000	6.3	7.4	–	6.8

FIGURE 4P

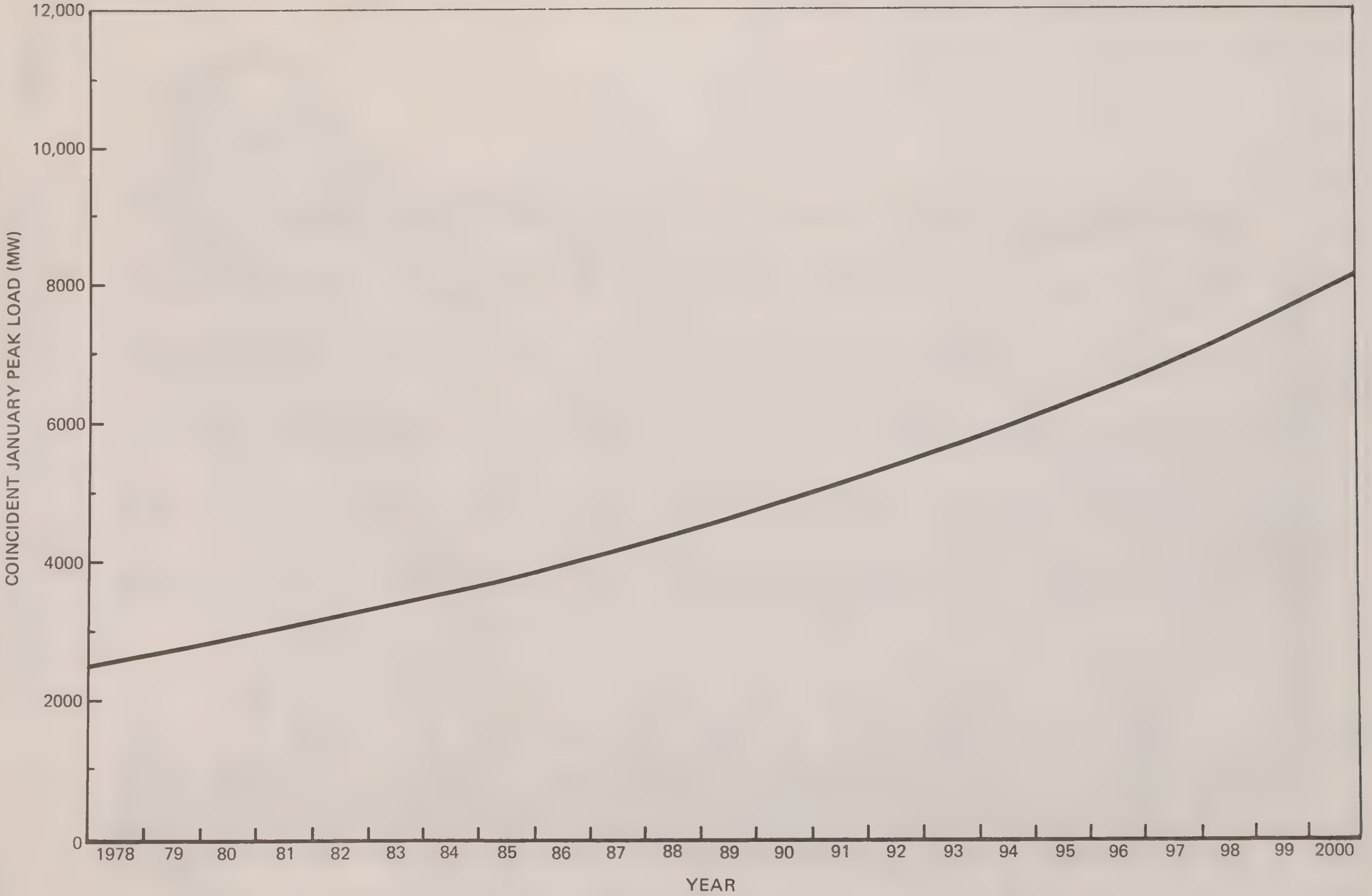
OPERATING AREAS IN SOUTHWESTERN ONTARIO
ACTUAL AND FORECAST DECEMBER PEAK LOADS

FIGURE 5

FORECAST OF SOUTHWESTERN ONTARIO CRITICAL AREA STATION LOADS COINCIDENT WITH JANUARY PEAK (MW)

STATIONS	1979	1981	1987	1991	1996	2001
AYLMER	18.0	20.5	27.7	33.6	42.9	54.6
ESSEX	95.0	87.5	113.6	136.7	167.5	199.2
LONDON HIGHBURY 13.8 kV	24.6	24.7	24.8	29.7	37.0	46.0
LONDON HIGHBURY 27.6 kV	88.1	93.8	101.6	123.1	156.0	197.3
INGERSOLL	42.0	47.5	66.8	82.5	107.2	138.5
J. C. KEITH	66.7	76.3	110.1	142.4	194.2	260.5
KENT TS	125.7	144.8	209.1	273.4	374.0	500.0
KINGSVILLE	67.3	76.4	110.1	146.7	205.5	279.4
LAMBTON	43.7	51.8	65.9	83.6	111.8	149.2
LONDON CLARK	73.9	78.3	85.3	104.5	133.9	170.8
LONDON NELSON	80.5	86.1	86.9	104.0	129.8	161.3
LONDON WONDERLAND	111.2	80.6	106.9	131.2	168.6	215.8
SARNIA MODELAND	–	82.6	127.9	162.6	215.9	284.6
SARNIA ST ANDREWS	150.7	90.9	106.0	125.4	153.0	185.9
STRATHROY	38.7	54.1	80.4	105.0	144.7	197.5
ST THOMAS 13.8 kV	30.6	30.8	36.6	44.6	57.1	73.2
ST THOMAS 27.6 kV	50.1	51.8	79.2	98.8	130.1	170.7
TILLSONBURG	44.9	50.3	68.4	85.1	111.9	146.9
SARNIA VIDAL	15.1	15.5	16.9	20.2	24.6	29.7
WINDSOR WALKER	81.5	61.3	79.6	95.8	117.3	139.5
WALLACEBERG	38.5	44.6	62.6	79.8	107.6	144.3
WANSTEAD	28.3	33.2	52.4	68.4	93.9	127.7
WINDSOR CRAWFORD	62.6	51.3	66.7	80.2	98.2	116.8
WINDSOR LAUZON	109.7	124.3	171.3	217.8	288.8	375.5
WOODSTOCK	61.0	68.4	91.1	111.4	141.9	177.2
LONDON TALBOT 13.8 kV	–	5.5	37.8	45.3	56.5	70.2
LONDON TALBOT 27.6 kV	–	50.5	104.2	124.7	155.7	193.3
WINDSOR MALDEN	–	66.5	86.3	103.8	127.2	151.3
BRANT	47.6	53.2	53.8	67.4	86.3	107.6
BRANTFORD	113.9	132.6	115.1	140.0	170.5	204.3
DETWEILLER	25.9	28.9	–	–	–	–
ELMIRA	27.4	32.1	11.3	14.1	17.9	22.7
FERGUS	67.4	77.7	50.8	64.4	85.6	113.3
GALT	135.7	152.0	90.9	109.1	136.9	171.8
GUELPH CAMPBELL	68.0	79.6	100.5	124.9	163.5	214.0
GUELPH CEDAR	66.7	78.0	143.0	177.7	232.7	304.4
KITCHENER GRABER	50.3	56.0	74.8	92.4	119.8	155.2
KITCHENER 3	65.9	73.4	67.5	83.3	108.0	139.9
KITCHENER 4	89.8	100.1	103.1	127.2	165.0	213.6
NORFOLK	57.7	63.2	–	–	–	–
PRESTON EAST	–	–	115.8	139.5	175.3	219.9
WATERLOO RUSH	33.9	37.4	48.4	57.8	72.0	89.7
WATERLOO SCHEIFELE	48.7	53.7	69.1	82.3	102.4	127.4
LYNDEN ROAD	–	–	112.3	136.5	167.8	198.3
WILMOT CENTRE	–	–	41.4	53.0	70.1	91.8
WOLVERTON	11.6	12.8	17.8	22.5	29.3	37.9
KITCHENER SW	–	–	61.3	75.7	98.2	127.2
WOOLWICH	–	–	52.7	66.8	89.1	118.1
ROCKWOOD	–	–	56.8	69.9	90.0	115.6
DIRECT INDUSTRIAL	158.8	178.9	247.4	295.0	356.0	425.0
TOTAL LOAD	2 618.0	2 959.5	4 010.0	4 959.8	6 389.2	8 154.9

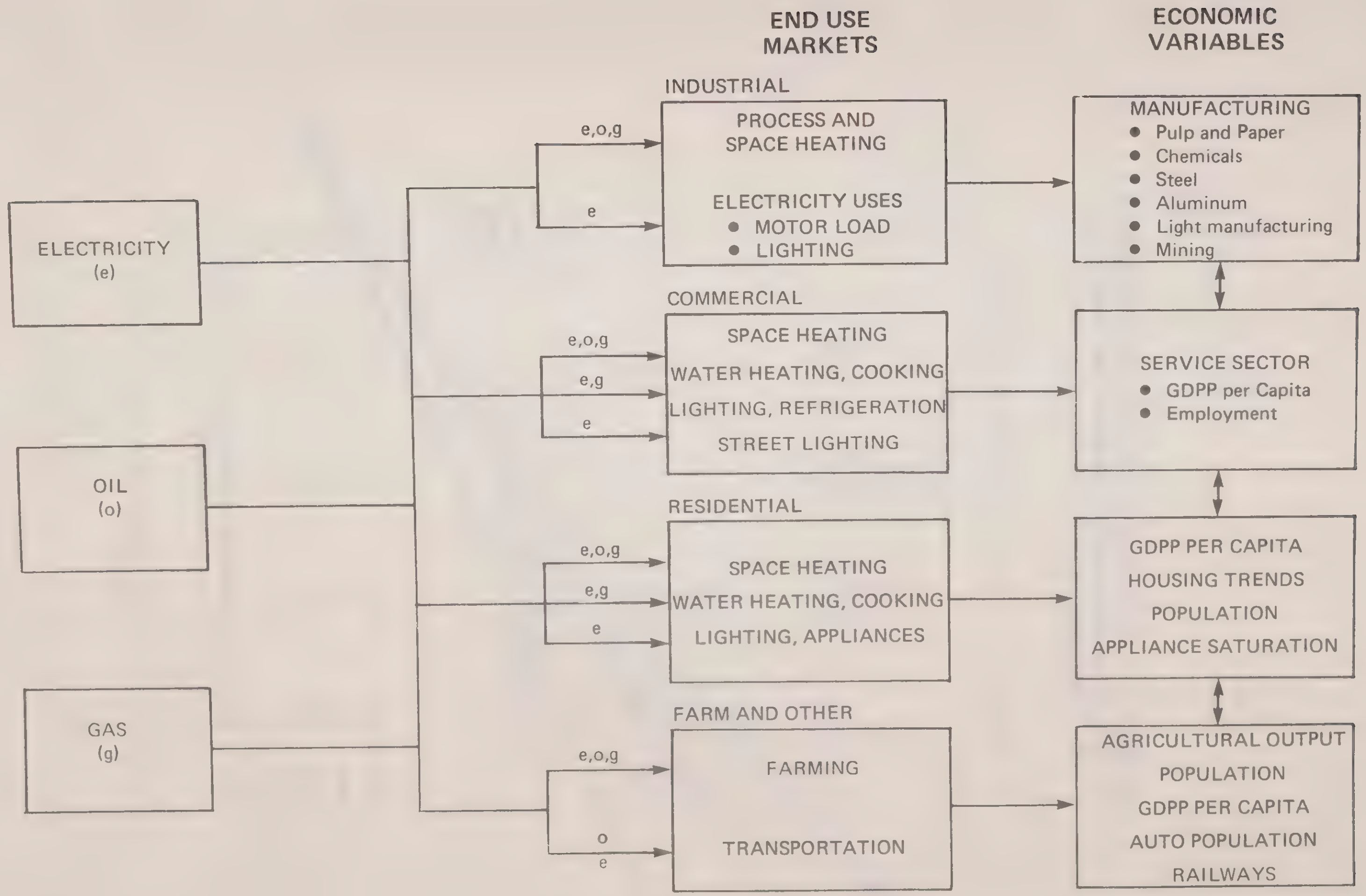
FIGURE 6



SOUTHWESTERN ONTARIO
CRITICAL AREA LOAD GROWTH

FIGURE 7

FIGURE 7



CONCEPTUAL FRAMEWORK FOR SRI–CEA MODEL

FIGURE 8

FIGURE 8

EFFECT OF VARIATIONS IN GROWTH RATE OF GROSS DOMESTIC PROVINCIAL PRODUCT ON GROWTH IN DEMAND FOR ELECTRIC ENERGY

A. Growth Rates in Gross Domestic Provincial Product

Time Period	Scenario #1 SRI Growth Rates %	Scenario #2 OEC Growth Rates % (Note 1)	Scenario #3 High Growth Rates %
1976 – 1981	3.8	5.3	5.5
1981 – 1985	3.8	4.4	5.5
1985 – 1990	3.8	4.1	4.5
1990 – 2000	3.2	4.1	4.5

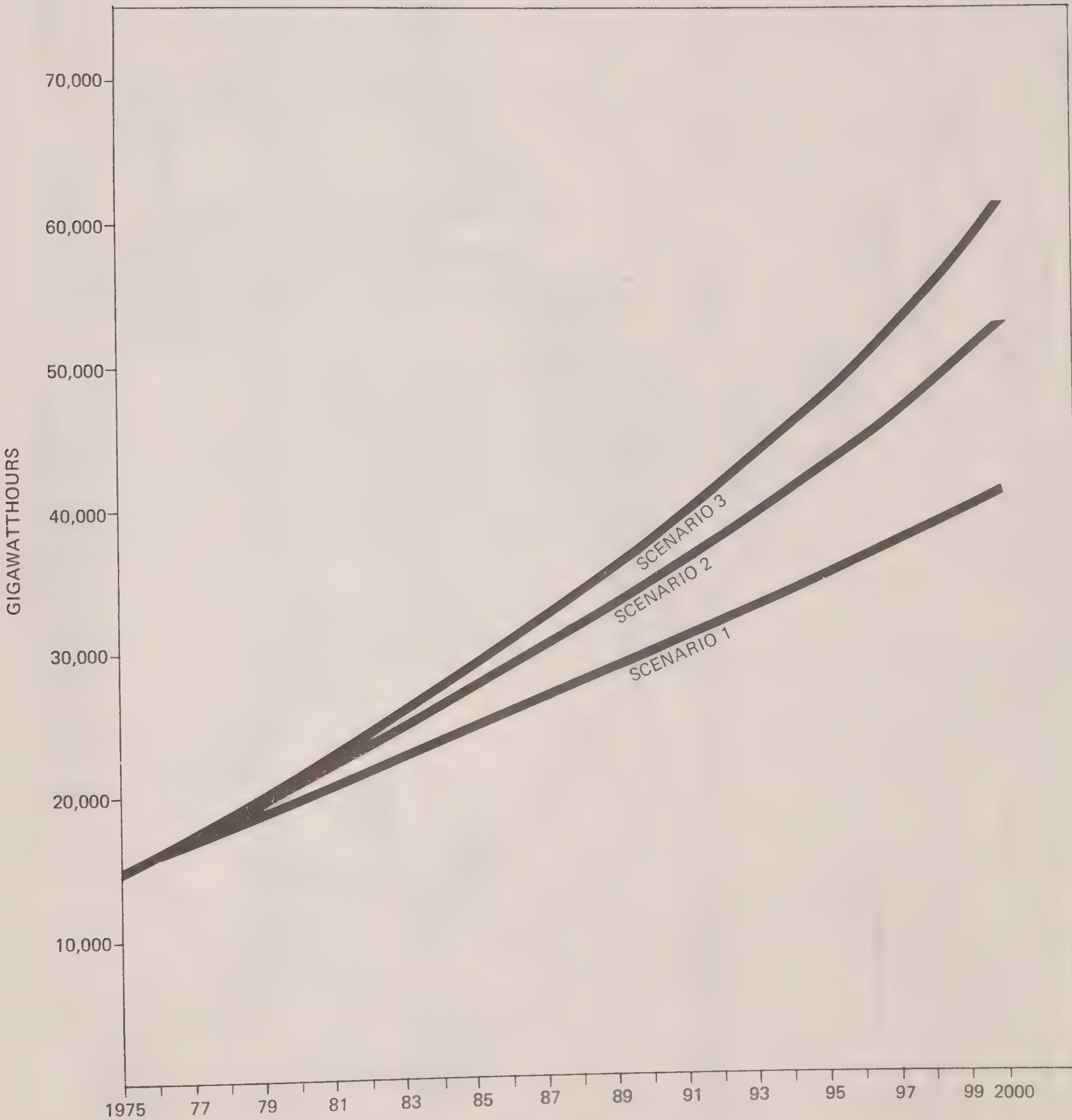
B. Resulting Growth Rates in Electric Energy Consumption

Time Period	#1	#2	#3	Ontario Hydro Forecast 780213 % (Note 2)
1976 – 1981	5.3	7.1	7.3	5.3
1981 – 1985	4.6	5.4	6.8	5.9
1985 – 1990	4.1	4.6	5.2	5.8
1990 – 2000	3.2	4.4	4.9	5.4

Note 1 These figures are approximations of year by year data given in the Ontario Economic Council (OEC) Report for the period to 1987.

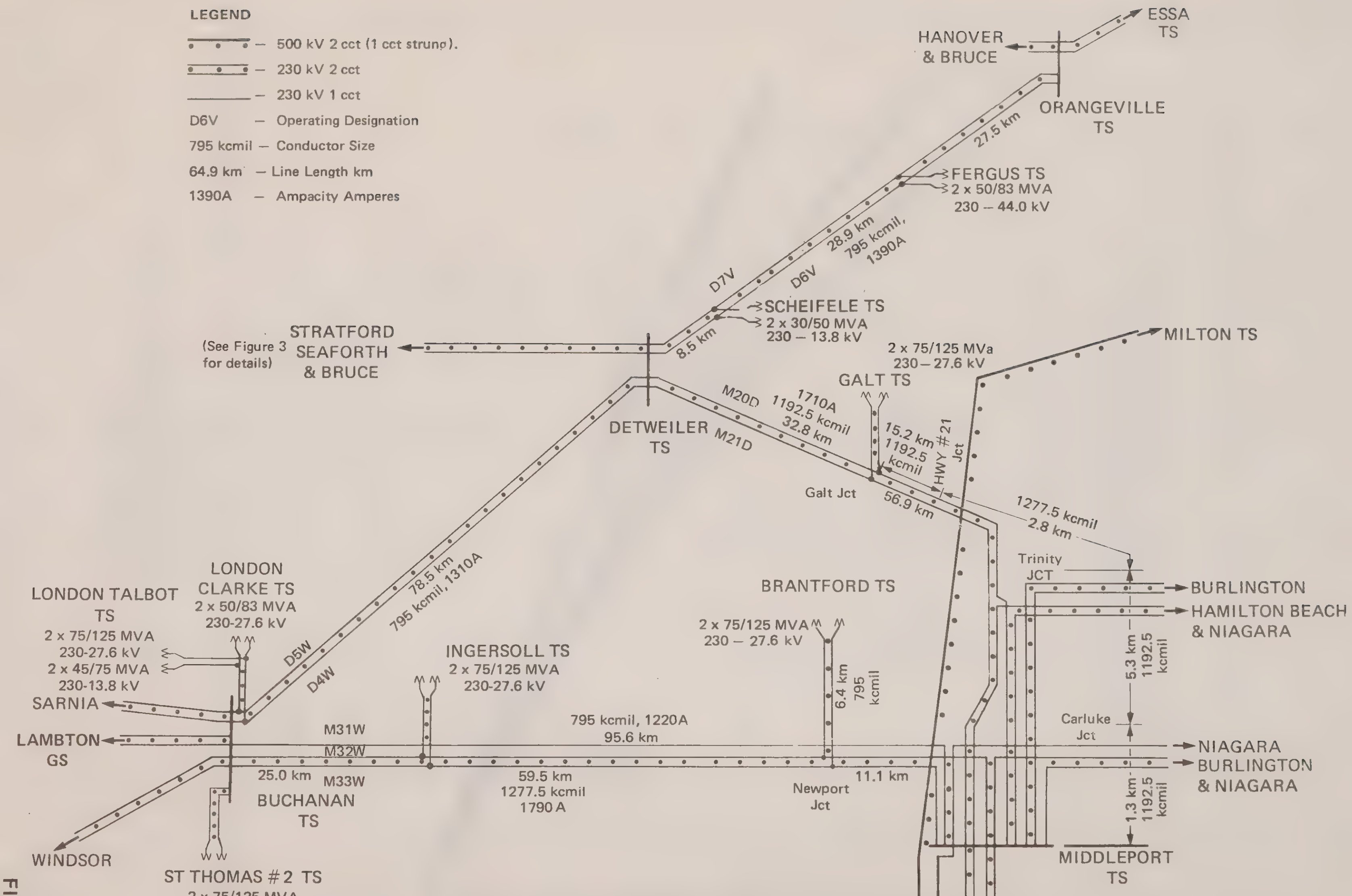
Note 2 The Ontario Hydro forecast growth rates are for December peak loads from figure 4.

FIGURE 9



SOUTHWESTERN ONTARIO
SRI – CEA MODEL FORECAST OF ELECTRIC
ENERGY GROWTH

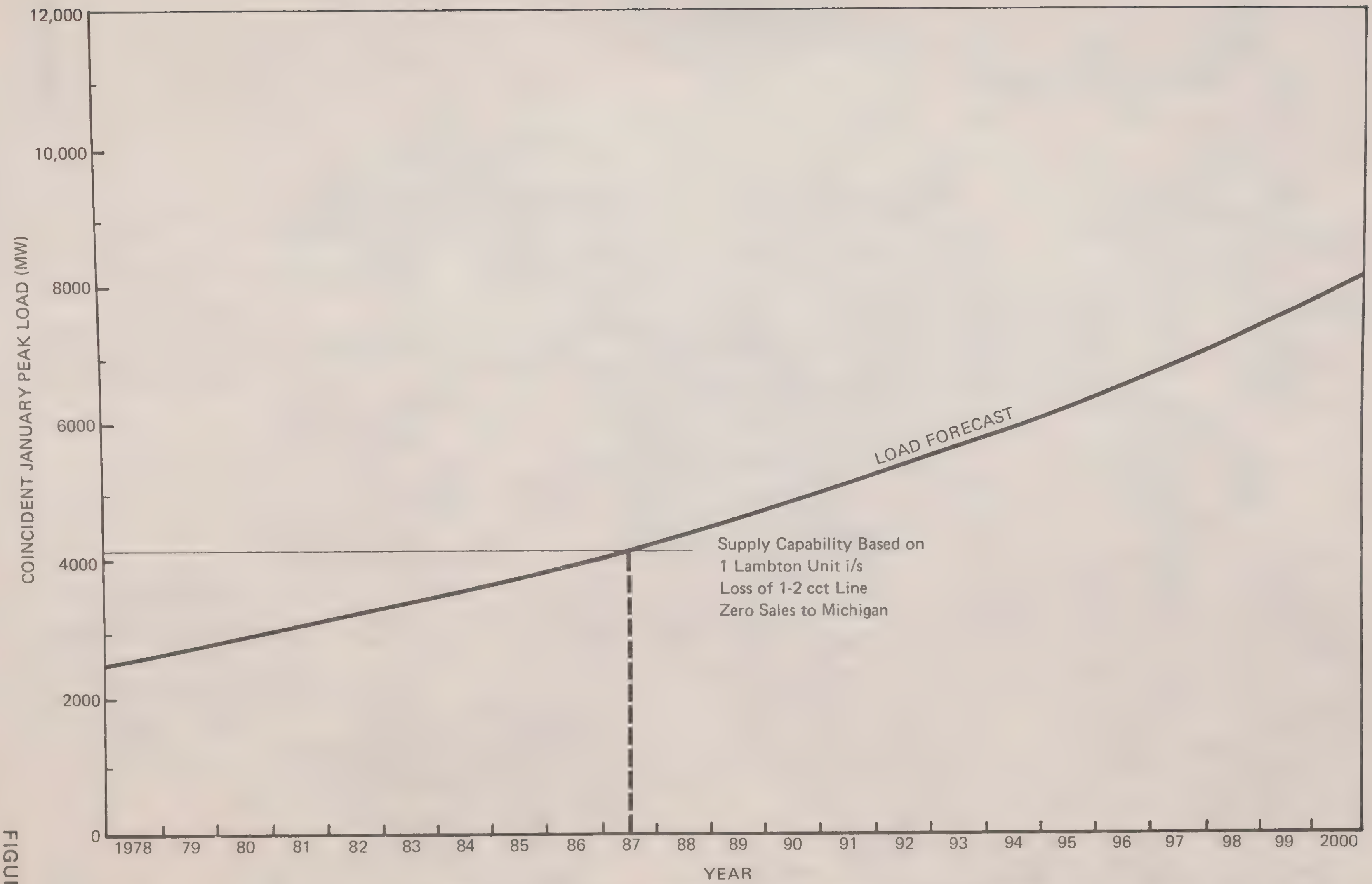
FIGURE 10



SOUTHWESTERN ONTARIO SUPPLY FACILITIES
RATINGS OF CRITICAL CIRCUITS
(BEFORE COMPLETION OF PLANNED WORK)

FIGURE 11

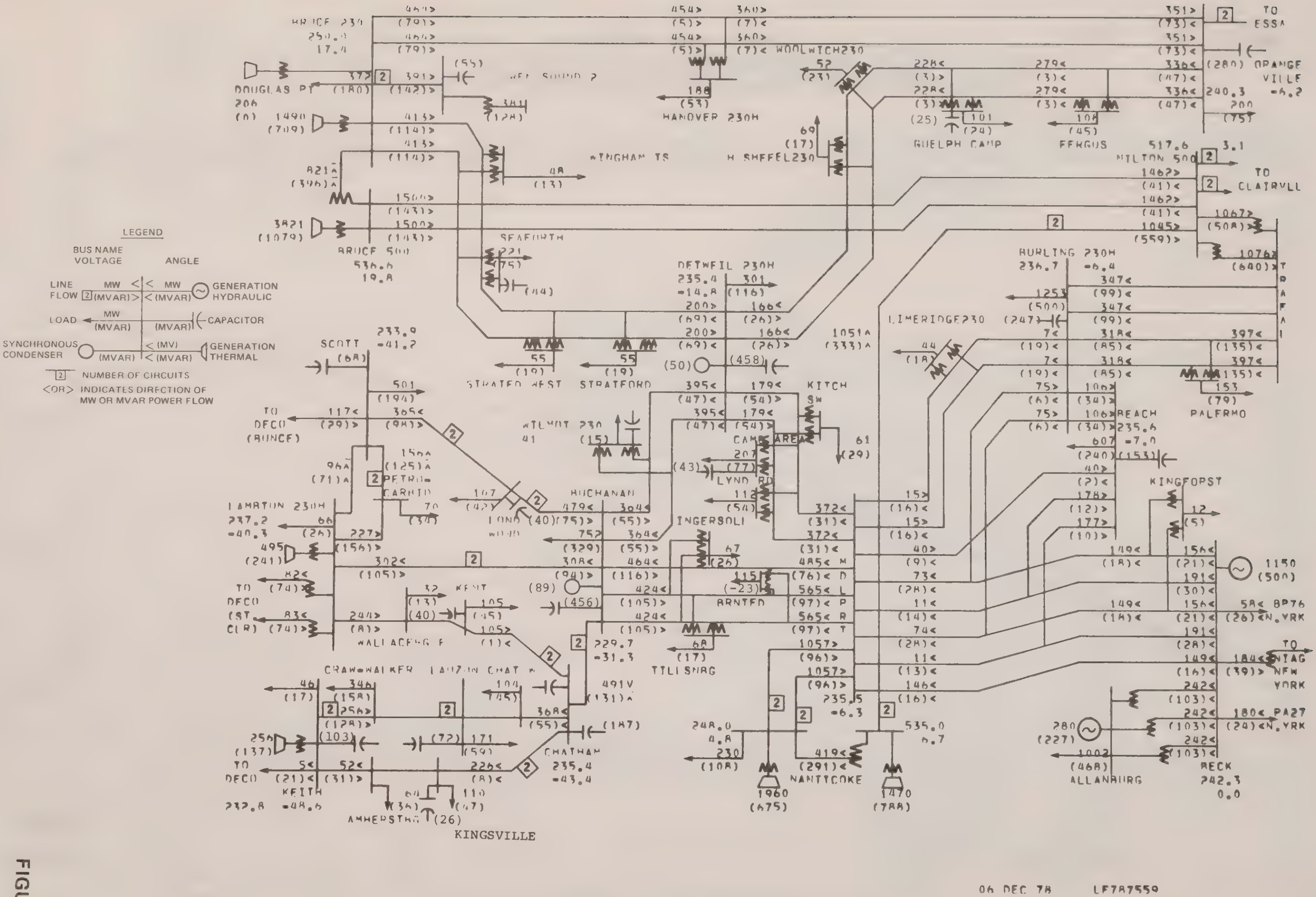
FIGURE 11



CAPABILITY OF EXISTING BULK POWER TRANSMISSION SYSTEM
FOR SUPPLY OF SOUTHWESTERN ONTARIO
CRITICAL AREA LOAD

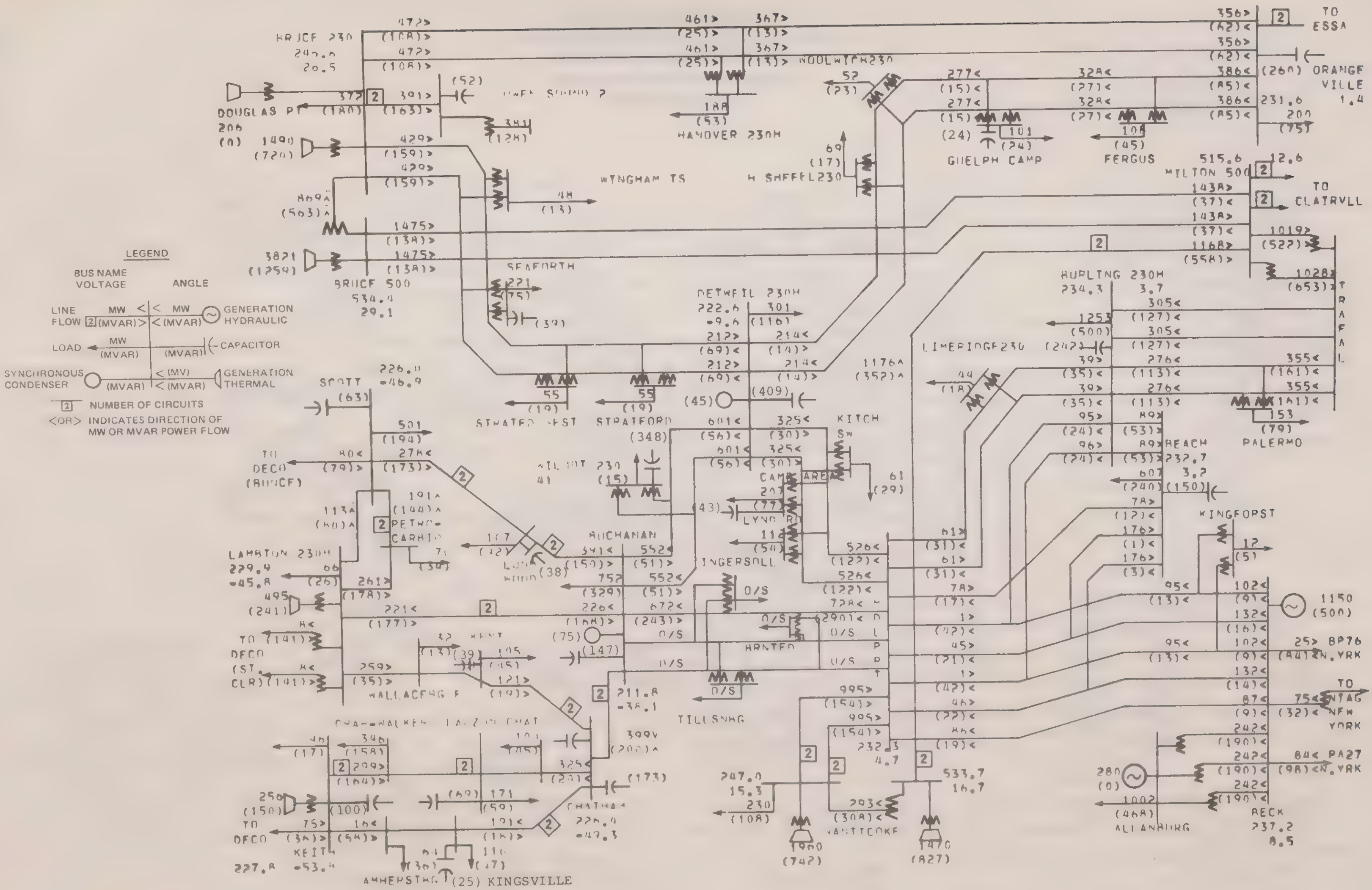
FIGURE 12

FIGURE 12



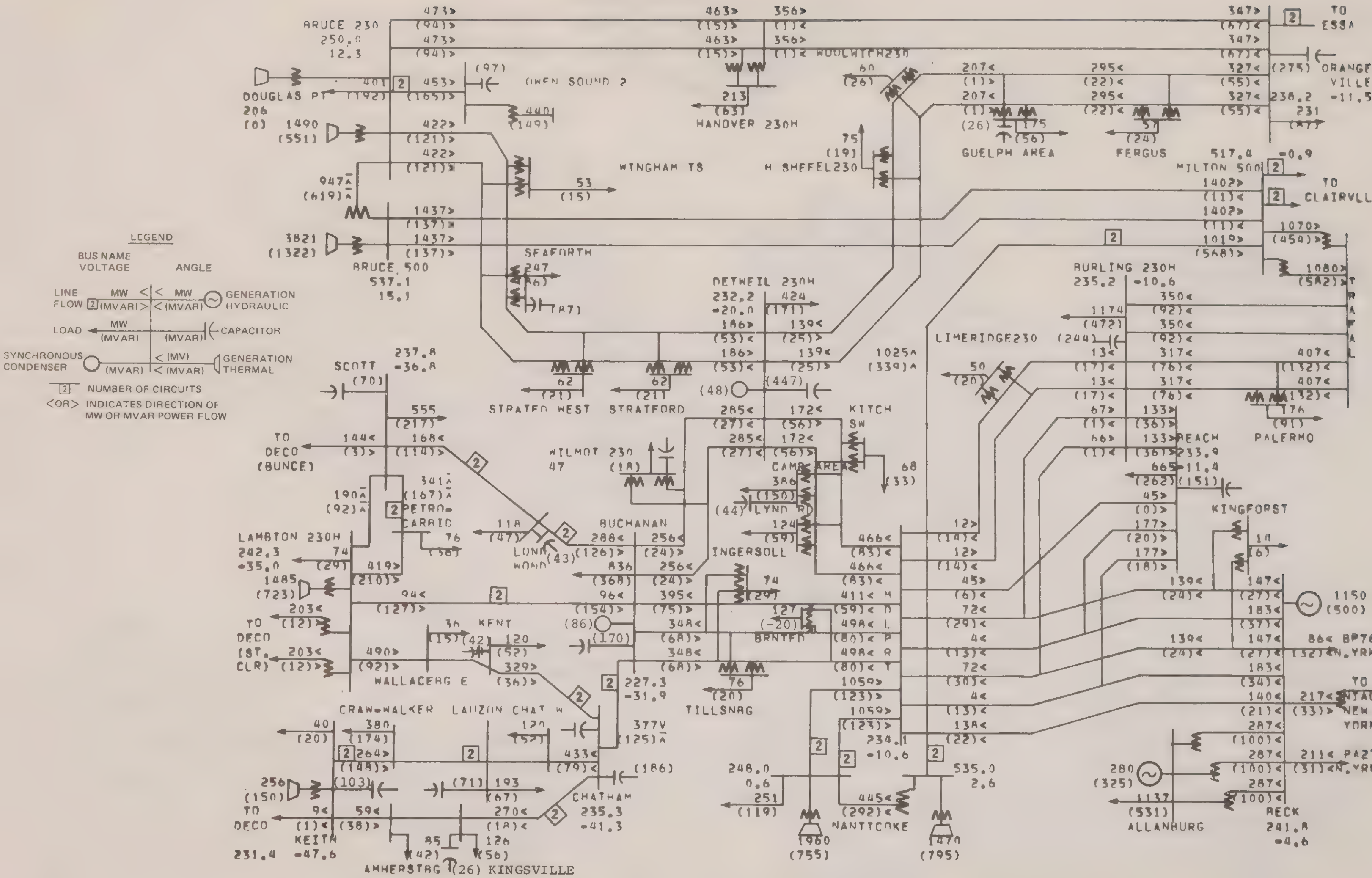
LOAD FLOW PLOT
JANUARY 1987 PEAK LOAD
O MW SALES TO MICHIGAN
1 UNIT IN-SERVICE AT LAMBTON
ALL FACILITIES IN SERVICE

FIGURE 13A



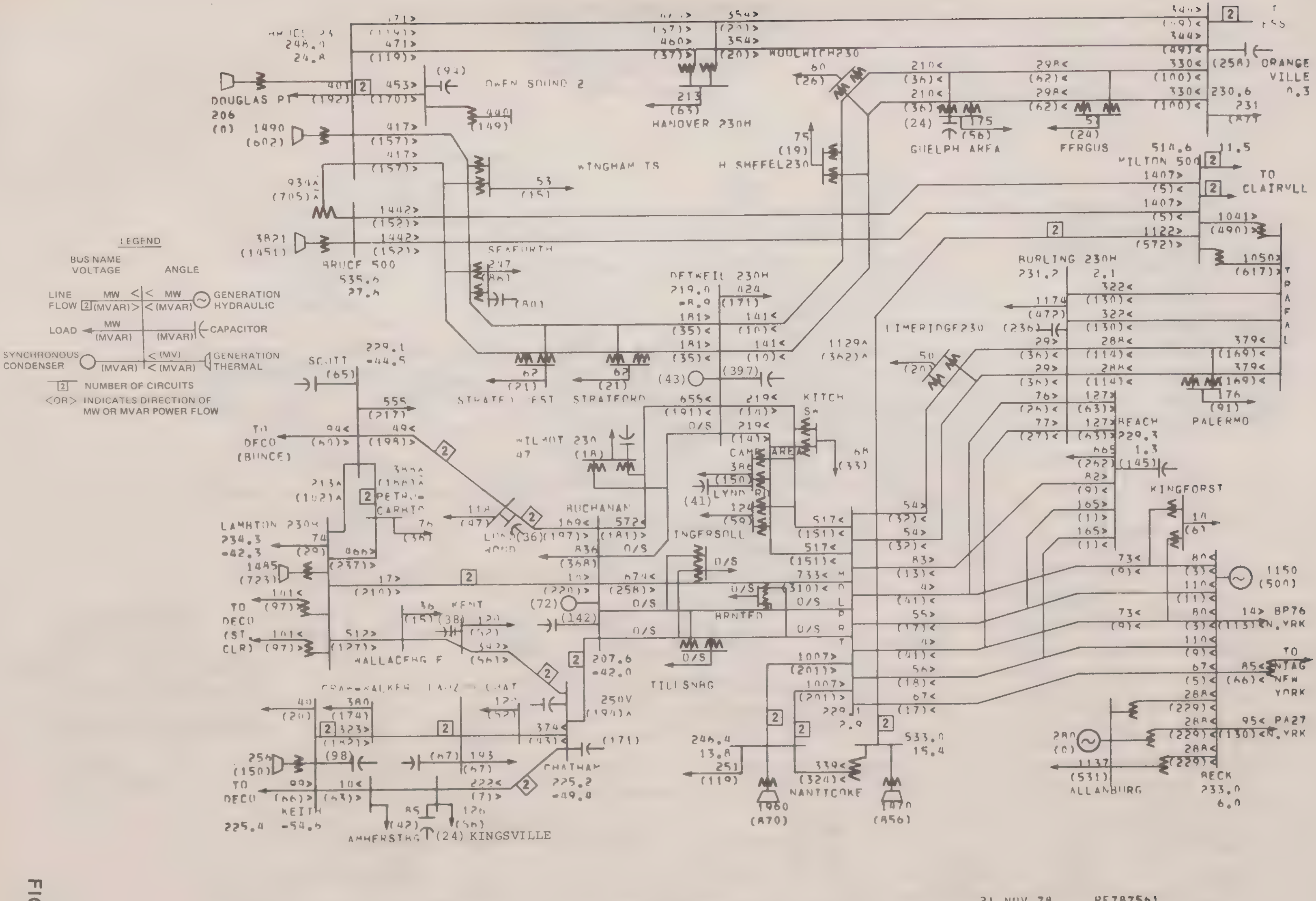
LOAD FLOW PLOT
JANUARY 1987 PEAK LOAD
O MW SALES TO MICHIGAN
1 UNIT IN-SERVICE AT LAMBTON
M32W AND M33W OUT-OF-SERVICE

FIGURE 13B



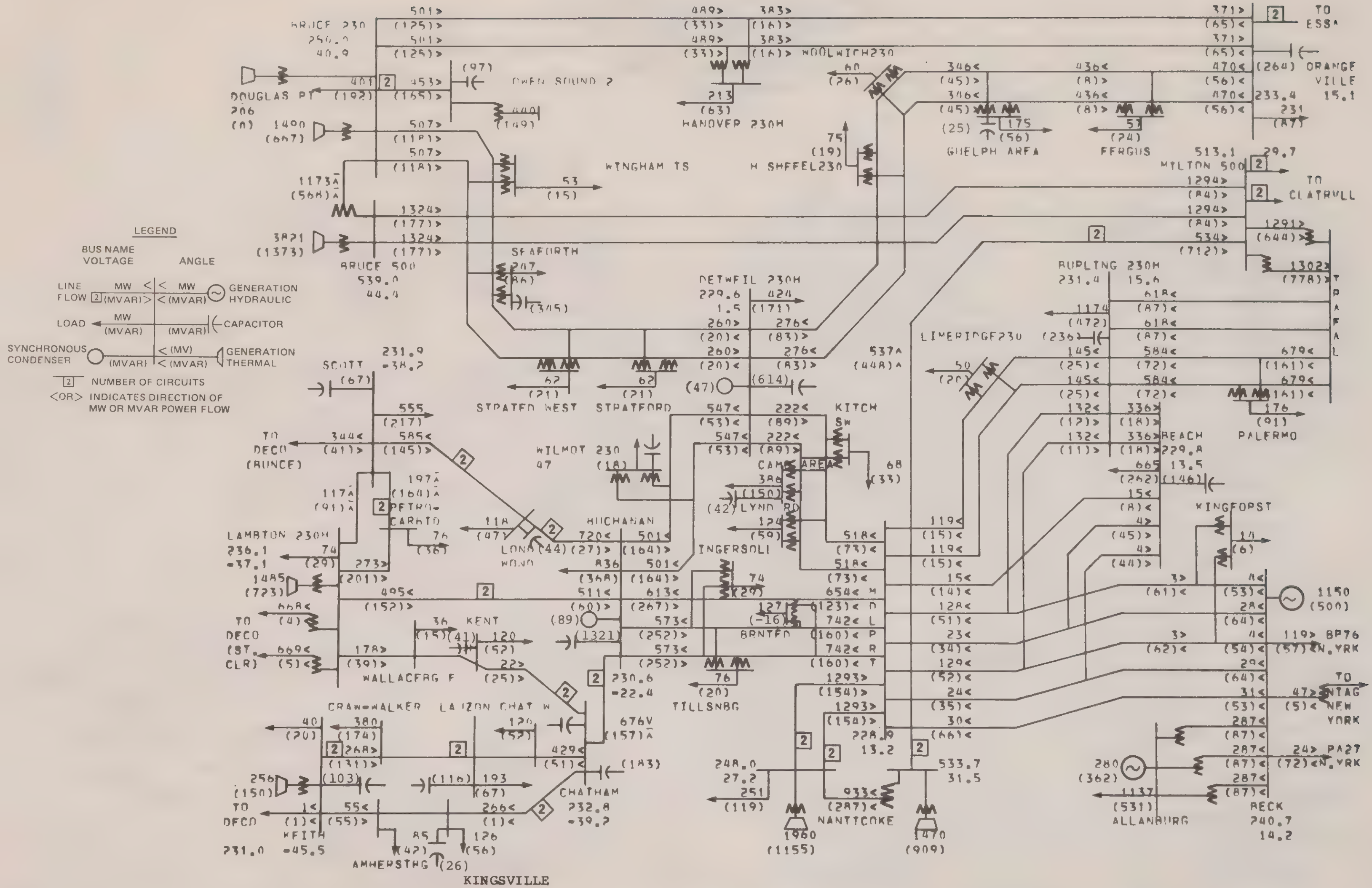
LOAD FLOW PLOT
JANUARY 1989 PEAK LOAD
O MW SALES TO MICHIGAN
3 UNITS IN-SERVICE AT LAMBTON
ALL FACILITIES IN-SERVICE

FIGURE 14A



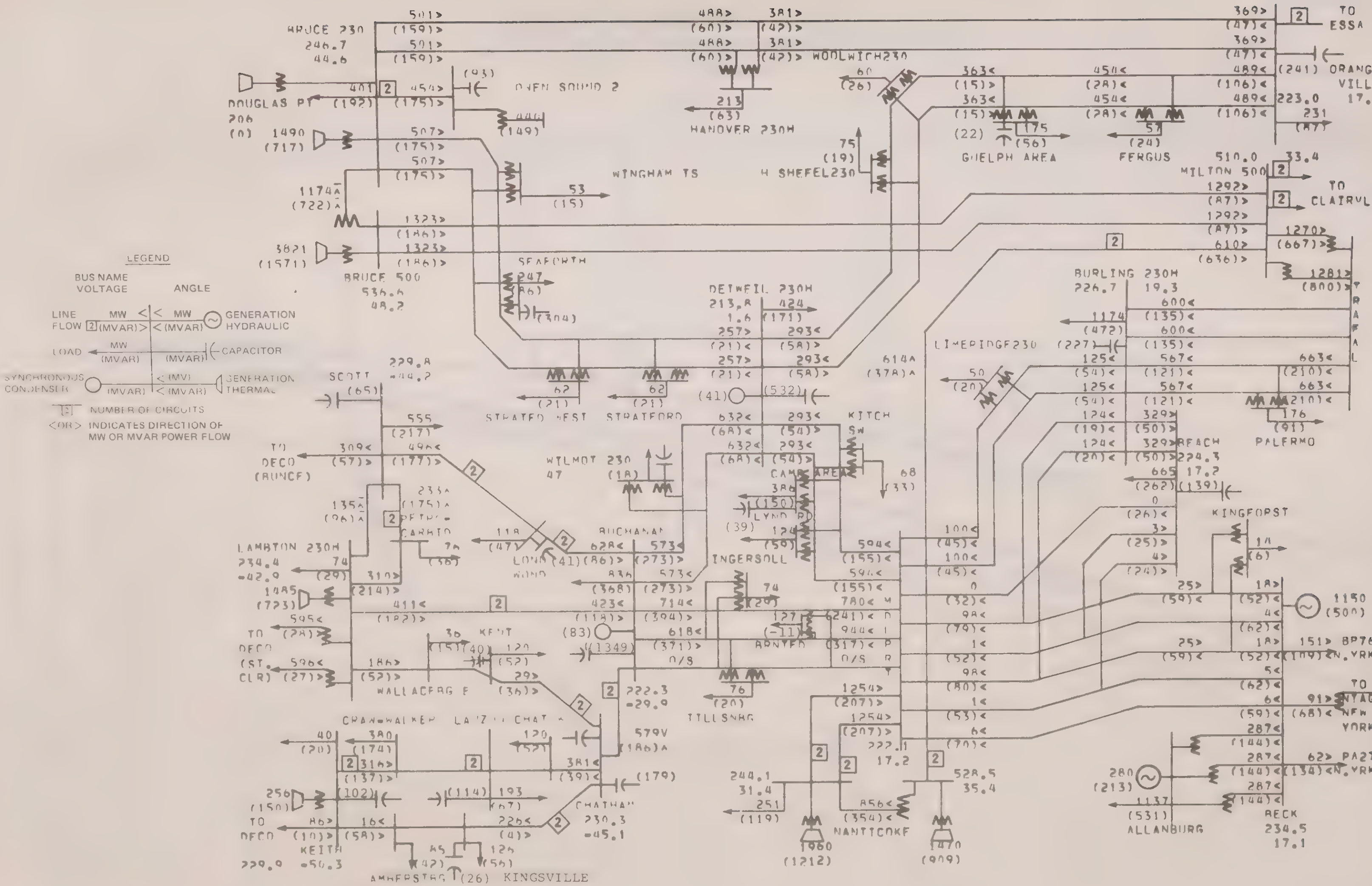
LOAD FLOW PLOT
JANUARY 1989 PEAK LOAD
O MW SALES TO MICHIGAN
3 UNITS IN-SERVICE AT LAMBTON
D4W, M32W AND M33W OUT-OF-SERVICE

FIGURE 14B



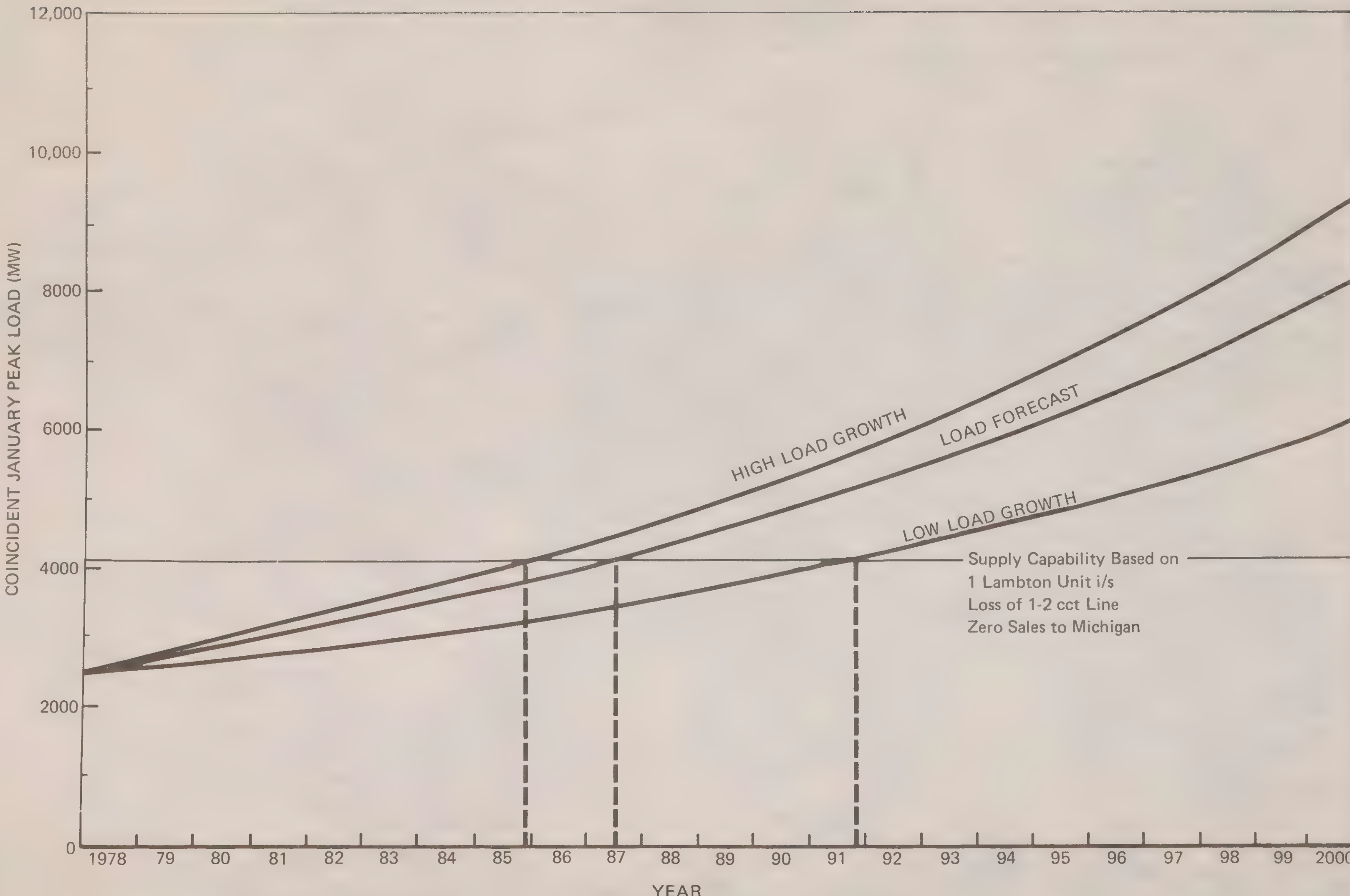
LOAD FLOW PLOT
JANUARY 1989 PEAK LOAD
2000 MW SALES TO MICHIGAN
3 UNITS IN-SERVICE AT LAMBTON
ALL FACILITIES IN-SERVICE

FIGURE 15A



LOAD FLOW PLOT
JANUARY 1989 PEAK LOAD
2000 MW SALES TO MICHIGAN
3 UNITS IN-SERVICE AT LAMBTON
M32W OUT-OF-SERVICE

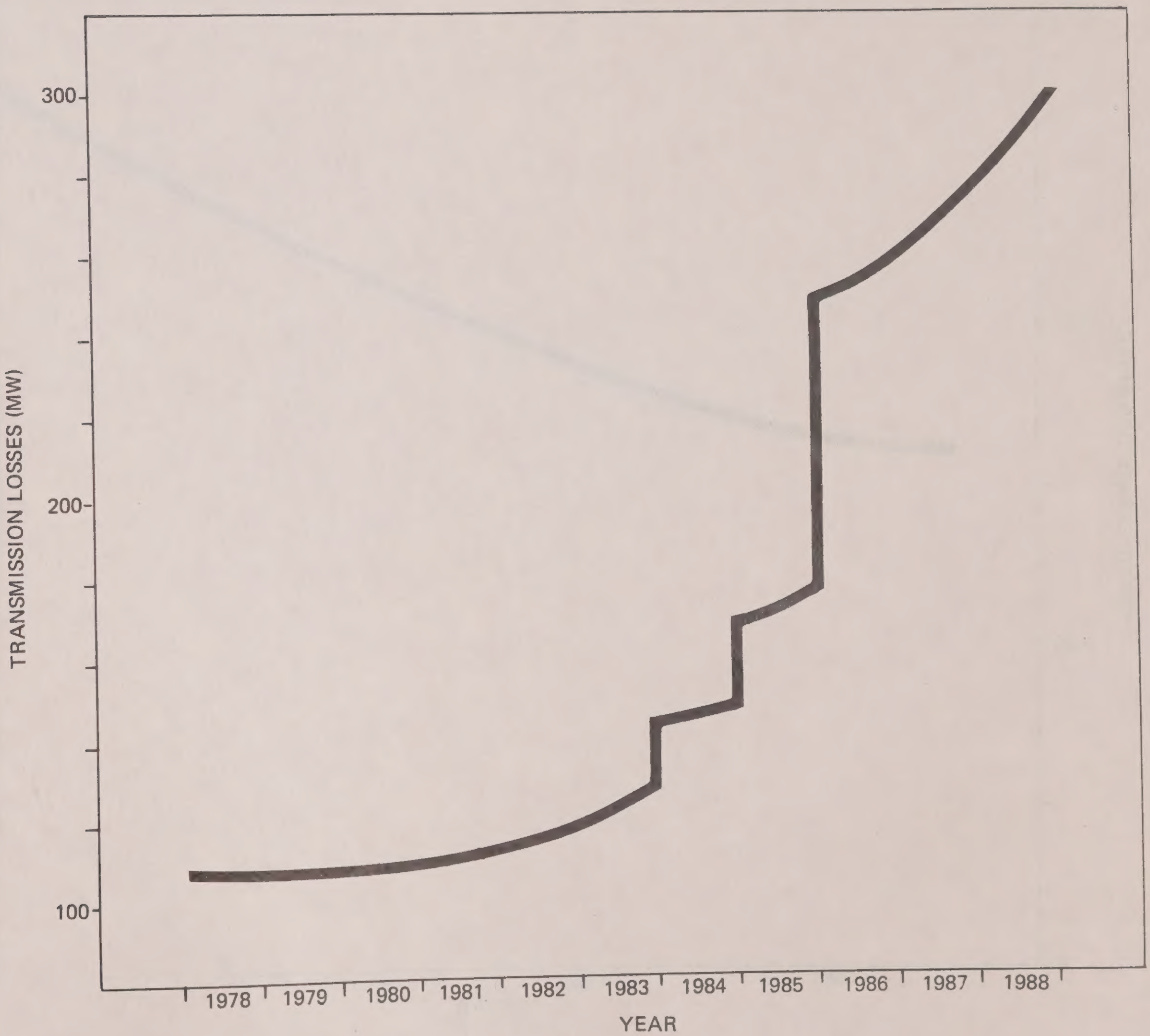
FIGURE 15B



HIGH AND LOW LOAD GROWTH CURVES FOR SOUTHWESTERN ONTARIO CRITICAL AREA LOAD

FIGURE 16

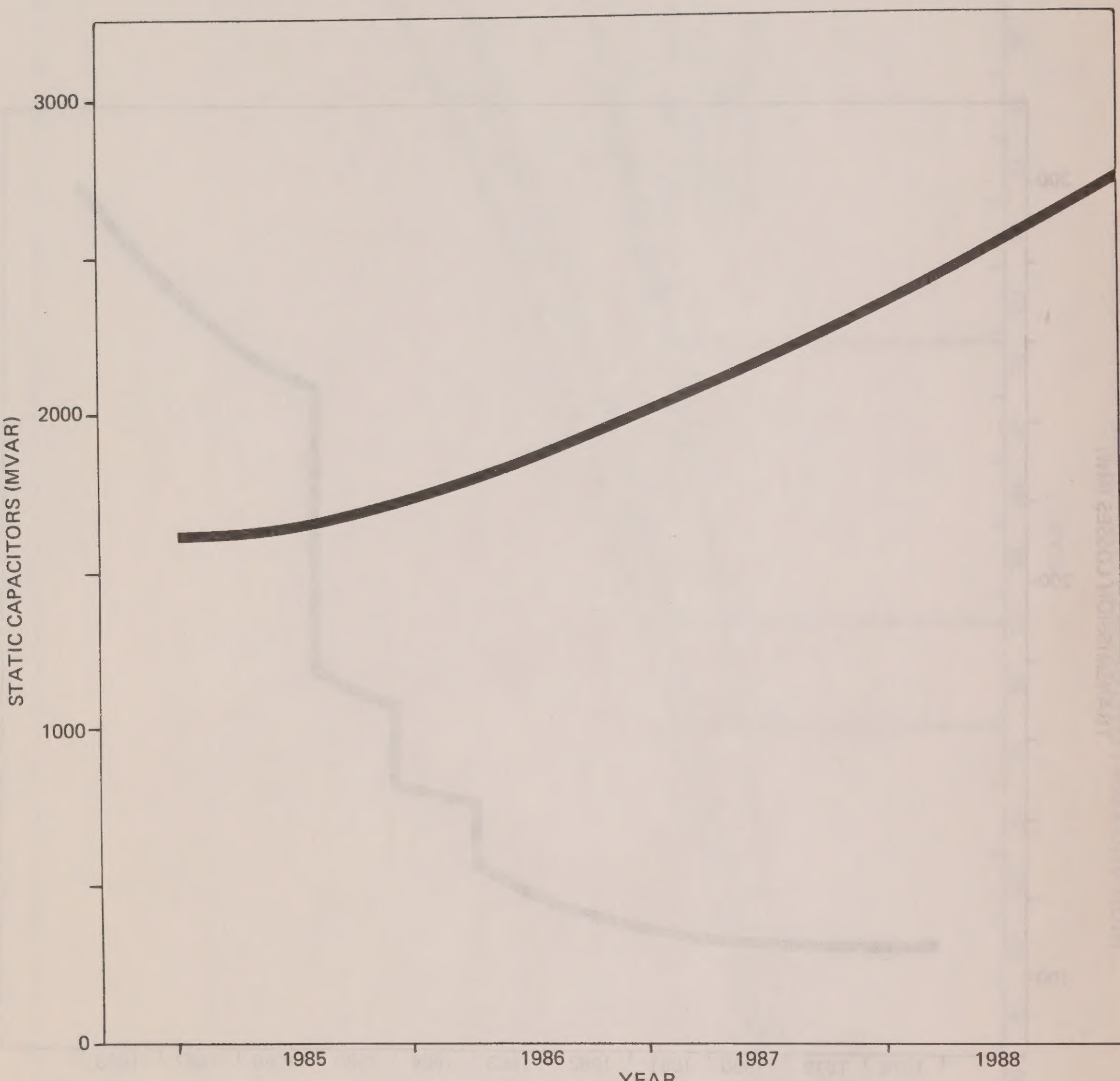
FIGURE 16



SOUTHWESTERN ONTARIO
POWER LOSSES IN TRANSMISSION FACILITIES AT
TIME OF SYSTEM PEAK

(With All Transmission Facilities In Service and Without Major New Additions)

FIGURE 17



SOUTHWESTERN ONTARIO CRITICAL LOAD AREA
STATIC CAPACITOR REQUIREMENTS
FOR LOAD SUPPLY

FIGURE 18